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15. Supplementary Notes

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16. Abstract (MAXIMUM 200 WORDS)

This report describes the continuance of an effort by the Coast Guard in collaboration with other Federal, state, and local agencies, private industry, and international interested parties, to gain practical knowledge and field experience in the coordination and operation of equipment, and exploration of techniques applicable to the recovery of oil spills in ice-infested waters. The effort explored and demonstrated a variety of commercial oil skimmers, boom capturing, and fire cannon herding equipment in rubble and sheet ice conditions during January 2012 in the Straits of Mackinac on the Great Lakes in northern Michigan. The demonstration produced many valuable 'lessons learned' that are applicable to ice-infested waters within the continental United States and in the Arctic waters of Alaska.

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- USCG National Strike Force
- CGC Hollyhock
- National Oceanic and Atmospheric Administration (NOAA)
- Michigan Department of Environmental Quality (DEQ) Water Resources
- Enbridge Pipeline

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EXECUTIVE SUMMARY

The U.S. Coast Guard (USCG), Environmental Protection Agency (EPA), local states, and the Canadian Coast Guard (CCG) routinely respond to oil spills during the winter months in the Great Lakes areas. Increasing vessel and barge traffic increases the potential for additional accidental discharges. While oil recovery issues have come to the attention of responders, researchers, and other stakeholders, work continues on improving response capabilities under possibly harsh conditions.

Cold climate conditions including the presence of ice complicate a response effort. Studies investigating the behavior of oil, current capabilities, and data gaps over the past two decades have helped increase our understanding of processes that take place during a spill. In spite of this, there is a need for more work to improve response capabilities.

This effort is the second in a series of planned on-water demonstrations to assess current spill response capabilities for use in ice infested waters. One objective of this demonstration was to identify operational performance gaps and acquire lessons learned. The design of this project is to leverage the needs and requirements of both Arctic and Great Lakes environments in order to identify equipment and techniques that would work in both locations to recover spilled oil.

This report centers on a 4-day field demonstration during which a select group of local Oil Spill Response Organizations (OSROs) had the opportunity to demonstrate selected equipment with potential for use in ice-infested waters. As part of the goal of collecting information on equipment staging and operation, requirements for offloading, set-up, and deployment as well as operations were noted.

Several apparatus were deployed and tested over the 2-day 'on the water' portion of the demonstration.

A grooved drum skimmer with a steam/hot water hook-up was briefly deployed in and among broken rubble ice. The device had problems with the steam line freezing over night and did not have enough weight to displace the surrounding ice rubble to have the drum surface sufficiently contact the water surface. Additionally, the device did not appear rugged enough to stand up to a continual pounding contact with ice. This device appears to be a better candidate for use in open water or quiet pools.

The DESMI PyroBoom® was deployed by two tugboats and was able to successfully capture and tow a quantity of ice broken from the ice pack by actions of one of the tugs. To maintain ice in the 'pocket' of the boom, towing speed had to be kept to a minimum. The ability of the tugboat to operate at a slow speed makes it ideal for the process as opposed to a vessel that must continually clutch its prop in and out to limit headway.

A self-contained fire monitor was demonstrated as a means of guiding or directing an oil spill surrogate consisting of peat moss and oranges into a pocket formed by the hull of the Coast Guard Buoy Tender (WLB) Hollyhock with bow 'nosed into' the ice sheet and adjacent sheet ice edge. While slow and a bit tedious, this method appeared to work, but moving larger pieces of rubble ice with the water jet was difficult. This concept appeared to function well as the water jet from the fire monitor covered a wide area that would have been covered with oil. For this demonstration, the fire monitor was stern-mounted. Bow-mounting the water cannon may have made vessel handling and positioning easier.

A rope-mop skimmer was briefly deployed. While it appeared to operate successfully, it should be deployed in more open water for maximum efficiency. High winds made it difficult to deploy the rope mop and have it fully engage with the water.

The DESMI Helix skimmer was successfully deployed from the Coast Guard Cutter (CGC) Hollyhock, both under rubble and sheet ice conditions. Manipulation and positioning of this skimmer worked best when slung from the vessel's bow-mounted 750-pound crane block. The Helix fittings, hoses, and moving parts could be better ruggedized or armored to protect from impact by rubble ice.

The DESMI Polar Bear was briefly deployed until it was discovered that its brushes had not been completely cleaned from a previous deployment and were creating a slight sheen on the water surface.

The remotely operated vehicle (ROV) with ultraviolet (UV) fluorometer was deployed during the second day of on the water demonstrations. It showed great potential both as a means of locating oil concentrations under sheet ice and potentially as a means of positioning and manipulating oil recovery equipment beneath the ice.

The deployed equipment exhibited varying utility for spill clean-up under various ice conditions, with performance for each dependent on ice, wind, and weather conditions. Each appeared to perform more optimally under specific conditions. All were successfully staged and deployed. Several valuable 'lessons learned' regarding each of the deployed devices, vessels, tactics, and mission deployment were documented and their impact on spill recovery work was identified. Continued collaborative field demonstrations in the Great Lakes and Alaskan Arctic under more severe weather and ice conditions, with continued use of an environmentally benign oil simulant, were recommended.

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LIST OF ACRONYMS

AIS	Automatic Identification System
CCG	Canadian Coast Guard
CG	Coast Guard
CGC	Coast Guard Cutter
CRREL	Cold Region Research and Engineering Laboratory
D17	District Seventeen
D9	District Nine
DEQ	Department of Environmental Quality
DRAT	District Response Advisory Team
DRMM	Dynamic Risk Management Model
EPA	Environmental Protection Agency
FL	Laser fluorometer
FOSC	Federal On-Scene Coordinator
ft	Feet [Foot]
gpm	Gallons per minute
GPS	Global Positioning System
HAZMAT	Hazardous material
HPU	Hydraulic power unit
IAP	Incident Action Plan
ICC	Incident Command Center
ICS	Incident Command System
IMD	Incident Management Division
IMO	International Maritime Organization
ISB	In-situ burning
km/h	Kilometers per hour
lb	Pound
mm	Millimeter
MPC	Marine Pollution Control
mph	Miles per hour
N/A	Not available
NOAA	National Oceanic and Atmospheric Administration
NSFCC	National Strike Force Coordination Center
OIC	Officer in Charge
OSHA	Occupational Safety & Health Administration
OSRO	Oil Spill Response Organization
PAO	Public Affairs Office
PIAT	Public Information Assist Team
PPE	Personal protective equipment
psi	Pounds per square inch
RDC	Research & Development Center
ROV	Remotely operated vehicle

LIST OF ACRONYMS (Continued)

SAIC	Science Applications International Corporation
SME	Subject matter expert
SOP	Standard Operating Procedure
SORS	Spilled Oil Recovery System
SSE	South southeast
SSM	Sector Sault Ste. Marie
SSP	Site Safety Plan
SW	Southwest
T/V	Tugboat vessel
U.S.	United States
USCG	United States Coast Guard
UV	Ultraviolet
WLB	CG Seagoing Buoy Tender
WLM	CG Coastal Buoy Tender
WNW	West northwest
WTGB	CG Bay Class Icebreaking Tugboat

1 BACKGROUND

This effort was performed under Project 4701, Response to Oil in Ice. The Coast Guard (CG) does not have an accepted group of methodologies to minimize the damage to the environment caused by spilled oil in extreme cold either in the Arctic Region or the Northern states. The objective of this demonstration was to evaluate response capabilities in cold weather by leveraging CG and other local assets in the Great Lakes before conducting a more complex demonstration in Alaska. This is the second in a series of demonstrations, the first which occurred in Sault Ste. Marie in April, 2011.

There are multiple commercial, state, and international manuals that describe tactics that can be used in cold weather. These recommendations change depending upon weather conditions, ice conditions and the oil spill size, weathering, and movement. They are generally written for solid ice when personnel and equipment can be placed safely on the ice, and not for thin or broken ice which cannot support personnel and equipment. There is also a category of open water but operating when ice is serving as a barrier and the oil is sitting against it. The focus of this effort is to identify tactics that can be safely used in broken ice and near the ice edge by CG vessels and supporting local Oil Spill Response Organization (OSROs).

2 INTRODUCTION AND OBJECTIVES

In the northern climates of the United States, the CG, Environmental Protection Agency (EPA), local states, and the Canadian Coast Guard (CCG) routinely respond to oil spills during the winter months. Currently, the majority of the spills are tank leaks and gasoline truck accidents that may occur near waterways and thus the spilled oil can reach navigational waters like harbors and rivers. While the oil recovery issues have been generally addressed, reduced ice during some seasons may increase vessel and barge traffic. This factor, along with an aging pipeline infrastructure, increases the potential for accidental discharges. To address these concerns, and to take advantage of emerging oil recovery technologies, northern climate regions are re-evaluating the equipment and techniques that are available. Parallel efforts are being made in District 17 (D17) to increase the spill response capabilities off the North Slope of Alaska in anticipation of increased exploration, drilling, and shipping.

This effort was an on-water demonstration of current capabilities to identify operational performance gaps. This demonstration was built on the previous knowledge base and lessons learned, as well as taking advantage of new response developments. This project was designed to identify equipment and techniques that would work in both Arctic and Great Lakes environments.

This demonstration was comprised of a 4-day field deployment that included exploration and demonstration of tactics for oil recovery operations in frigid open water, under sheet ice, and in and among broken ice. During the demonstration, a select group of local Oil Spill Response Organizations (OSROs) demonstrated the ability of various types of spill response equipment to recover an oil surrogate (e.g., peat moss, oranges) from ice-infested water. See APPENDIX A for details of oil recovery systems that were demonstrated.

There were four vessels involved in the demonstration. The Coast Guard Cutter (CGC) Hollyhock is a buoy tender (Coast Guard Buoy Tender (WLB)) with ice-breaking capabilities. This vessel’s primary objective was to deploy and evaluate a new Coast Guard cold-weather skimming system. Three commercial tugboats, tugboat vessel (T/V) Erika Kobasic (United States (U.S.) registry), T/V Nickelena (U.S. Registry), and T/V

Reliance (Canadian registry), deployed commercial responders and their equipment. See APPENDIX B and APPENDIX C for vessel details.

Enbridge Pipeline also deployed local responders for shoreline response. Techniques such as slotting were attempted in a small cove just west of the Mackinac Bridge in northern Michigan. They also performed a table-top and simulated Incident Command System (ICS) demonstration.

Following each test period, a "hot wash" debrief session assessed performance and collected lessons learned.

2.1 Demonstration Participants

See APPENDIX D for participant names, organizations, and contact numbers.

- United States Coast Guard (USCG) Research & Development Center (RDC)
- CG District 9 (D9)
- Station St. Ignace
- Sector Sault Ste. Marie
- CG National Strike Force personnel
- Representatives from CG Districts 1, 5, 13, and 17
- Enbridge Pipeline, Co.
- EPA
- National Oceanic and Atmospheric Administration (NOAA)
- Observers (CG Headquarters, CCG, Michigan Department of Environmental Quality (DEQ))
- Science Applications International Corporation (SAIC))

2.2 Demonstration Concept

This demonstration focused on conducting simulated oil recovery from ice-infested waters. The material recovered consisted of the environmentally benign surrogate peat moss and oranges deployed by CGC Hollyhock and one of the two U.S. registry tugboats. Local OSROs demonstrated their ability to recover the material in adverse cold-weather conditions from shore and in slow-moving water, and shipboard in brash/rubble ice and among sheet ice.

2.3 Planning of Demonstration

The scenario was a leak from a pipeline in the open waters of the Mackinac Straits in northern Michigan. (See APPENDIX F for an area map.) A working group composed of representatives from RDC, D9, the National Strike Force Coordination Center (NSFCC), the U.S. EPA, NOAA, Michigan Department of Environmental Quality (DEQ), and Sector Sault Ste. Marie (SSM) held periodic teleconferences starting in August 2011. A private industry partner who owns the pipeline, Enbridge Pipeline, signed up to help fund a Canadian tugboat, deploy shoreline responders, initiate a limited Incident Command, and provide helicopter surveillance. The CGC Hollyhock (WLB-214) was assigned. Contracts were issued for two tugs to deploy response equipment, a local OSRO to supply the equipment, and crane and forklift service. The pier where CGC Biscayne Bay normally ties up was the staging and load out area. A total of four types of skimmers, a fire boom, and a remotely operated vehicle (ROV) were selected for demonstration. Icing problems on the pier were encountered on the first day but all equipment/material was loaded by the following morning.

2.4 Demonstration Schedule

Table 1 contains the high-level schedule for the field tests.

Table 1. Schedule of events.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
22 Jan. 2012	**23 Jan. 2012**	**24 Jan. 2012**	**25 Jan. 2012**	**26 Jan. 2012**	**27 Jan. 2012**
Travel	Brief and Load-out	On-Water Test Day 1	On-Water Test Day 2	Un-load and Out-Brief	Travel

2.5 Test Conditions (Weather and Ice)

Table 2 shows the test conditions under which this test was conducted.

Table 2. Test conditions: weather and ice.

Load-out Day: Monday, 23 January 2012	
Air Temperature:	minimum 29 °F; maximum 43 °F
Wind:	7 miles per hour (mph) to 12 mph, generally south southeast (SSE)
Maximum Wind Gusts:	25 mph
Precipitation:	0.63”, mixed snow/rain
Day 1: Tuesday, 24 January 2012	
Air Temperature:	minimum 23 °F; maximum 32 °F
Wind:	13 mph to 17 mph, generally west northwest (WNW)
Maximum Wind Gusts:	26 mph
Precipitation:	0.0”
Seas:	2-3 ft
Ice Conditions:	predominantly open water with large areas of unconsolidated floes, rafted ice, and rubble 3” to 9” thick
Day 2: Wednesday, 25 January 2012	
Air Temperature:	minimum 24 °F; maximum 32 °F
Wind:	3 mph to 7 mph, generally southeast (SE)
Maximum Wind Gusts:	not available (N/A) mph
Precipitation:	0.0”
Seas:	calm
Ice Conditions:	significant open water with large areas of continuous sheet ice 6” to 9” thick
Un-load Day: Thursday 26 January 2012	
Air Temperature:	minimum 24 °F; maximum 32 °F
Wind:	3 mph to 10 mph, generally SSE
Maximum Wind Gusts:	18 mph
Precipitation:	0.0”

3 THE DEMONSTRATION

3.1 Planning

The following planning occurred.

- Pre-demonstration meetings
  - Telephone conference calls were held, typically on a bi-weekly basis, to permit efficient communications, planning, coordination, and exchange of information among all participants.
  - Two in-person pre-demonstration meetings were held to permit introductions of the many Federal, state, and local Government agencies, the CG, private sector participants, and contractors.
    - A kickoff meeting was held on 19 October 2011 at the CG D9 headquarters in Cleveland, Ohio. This meeting brought together several participating CG entities and supporting Government agencies, as well as public sector participants and contractors. Introductions were made, history of earlier efforts was described, the general plan for this demonstration was explained, and several action items were assigned to the attendees.
    - A second in-person meeting was held in St. Ignace, Michigan at the local emergency response office on 8 December 2011. This meeting provided an opportunity to meet in-situ and coordinate with local governmental and private sector stakeholders and finalize logistics. The meeting included a visit to CG Station St. Ignace to meet personnel and to view facilities and infrastructure from where the demonstration would be staged.
- Federal Government inter-agency coordination
  - This was also done through the planning meetings. Specific topics such as NOAA's trajectory modeling support were coordinated directly and discussed during the planning meetings.
- State and municipal coordination
  - This was also done through the planning meetings when specific topics were coordinated directly and discussed.
- Private sector coordination (equipment and vessel suppliers)
  - RDC developed statements of work and followed the standard acquisition processes to award contracts for vessels and equipment.
- Public affairs
  - Public affairs and dissemination of information to the media was managed jointly by the CG Public Affairs Office (PAO) from D9, a representative from the CG Strike Force Public Information Assist Team (PIAT), and Enbridge's public affairs. It was seen to be important that the local communities, community leaders, Tribal leaders, and maritime commercial interests be well informed about the on-water and helicopter activities that would be occurring as part of this demonstration in and near the Straits of Mackinac.
- ICS
  - A major component of the demonstration planning document was consideration and inclusion of the necessary forms to comply with ICS practices.
  - As a separate demonstration, Enbridge fully staffed an Incident Command Center (ICC) as part of a related shoreline oil recovery drill.
- Environmental
  - The principal environmental issue was to obtain permission from the State of Michigan DEQ in order to employ limited quantities of peat moss and oranges as environmentally benign surrogates for an oil spill. The letter of permission appears in APPENDIX E.

4 LOGISTICS

4.1 Load-out

Load-out operations were conducted on Monday, 23 January 2012 in inclement weather conditions of freezing rain and sleet. Pier surfaces were ice coated and slippery and generally provided unsafe footing. Precipitation and temperatures had potential for inducing hypothermia in ill-equipped/clothed personnel. With safety being of paramount importance, great care was taken to prevent injuries or accidents. There were no adverse incidents. Roadway and pier sanding/salting was provided by a local municipal snow plow/spreader vehicle. Additional means of de-icing pier and walkways was performed by personnel from the Station and some of the OSROs.

In addition to the hazards presented by the icy roadway, the pier was crowded with authorized Government and privately owned vehicles belonging to the crewmembers of CGC Biscayne Bay. At the time of the demonstration, the Biscayne Bay was out on patrol elsewhere. The vehicles on the pier were locked and could not be moved out of the way. No keys were available at the Station office. These vehicles presented a challenge to load-out as well as the later un-load operations. Figure 1 illustrates the close quarters between the vehicles and a crane used for loading and un-loading equipment from the demonstration vessels.

Figure 1. Crowded loading area makes load-out difficult.

Another logistics issue became apparent when it was necessary to move an empty oil collection storage tank from the pier to where it could be crane-loaded onto the Hollyhock. Initially, it was thought that a lightweight forklift might be sufficient to transport the tank. It became immediately obvious that the weight and dimensions of the tank were beyond the capability of the forklift. A heavy-duty forklift from a nearby private business was pressed into service to safely transport the tank to where it could be loaded onto the Hollyhock. Figure 2 shows the under-sized forklift adjacent to the storage tank; Figure 3 depicts the tank being safely transported by an appropriately sized forklift.

Figure 2. Aborted attempt by small forklift to move empty oil collection storage tank.

Figure 3. Appropriate-sized forklift moving empty oil collection storage tank.

4.2 Un-load

Initial un-load activities were begun immediately upon vessel return to Station St. Ignace, at the completion of the demonstration, late in the afternoon of Wednesday, 25 January 2012. Some contract vessel operators were anxious to head back to their home moorings. The un-load operations were somewhat limited because most of the contract heavy equipment operators had finished their working day by the time the vessels arrived at the pier. The lateness of the day and approach of darkness also led to postponement of further un-load activities until the next day.

Un-load continued the morning of Thursday, 26 January 2012 and was mostly complete by mid-day. The weather for the un-load was significantly improved over the weather on the load-out day at the beginning of the demonstration. Limited maneuvering and loading space on the pier was similar to that experienced during load-out, three days earlier.

5 EQUIPMENT AND OPERATIONS

5.1 DESMI Helix Skimmer

5.1.1 DESMI Helix Skimmer: Day 1

The DESMI Helix skimmer, associated hoses, and control unit were easily crane-loaded and secured onto the deck of CGC Hollyhock. Assembly and interconnection of hydraulic lines and hoses was accomplished by the efforts of several crewmembers and District Response Advisory Team (DRAT) representatives in less than an hour. For many of the participating crew, this was the first time they had encountered this type of equipment. Having personnel with prior experience with the apparatus was of significant assistance. Color-coded hydraulic hoses and connectors would have enhanced safety, helped simplify, and sped up the equipment set-up process.

The ice conditions on Day 1 were suitable for demonstrating skimmer deployment in ice rubble. APPENDIX G provides details for this tactic. When CGC Hollyhock was fully surrounded by a rubble ice field, turbulence created by one of the vessel's bow thrusters was able to create a small water pocket into which the skimmer could be deployed. The skimmer, with all hoses connected, was hoisted over the side and directed in the water using the vessel's bow-mounted 'whip crane.' Figure 4 illustrates the deployment of the skimmer in an open-water pocket adjacent to the vessel's hull. The skimmer was manipulated and directed, with some difficulty, into an open water pool at greater distances from the vessel's hull. (Figure 5) In that configuration, the recovery hose and hydraulic lines dragged across the surface of the nearby rubble ice. Sections of the hoses sank beneath the surface in the open water adjacent to the skimmer. These conditions may lead to abrasion, pinching, and severing of the lines when impacted by larger ice rubble. It was also observed that below-waterline skimmer fittings and hydraulic and mechanical components are susceptible to damage from collision with masses of rubble ice. During this evolution, no oil surrogates were used.

Figure 4. Helix skimmer in open water pocket among rubble ice.

Figure 5. Helix skimmer deployed in open water pocket using 'whip' crane.

Upon system recovery from deployment, the skimmer was raised to a height that facilitated gravity drainage of the large diameter intake hose, permitting easier deck handling of the skimmer. Figure 6 demonstrates the raising of the skimmer to drain the intake hose prior to stowing the system on deck.

Figure 6. Draining Helix skimmer hose prior to recovery.

Observations from demonstration participants suggested that handles or 'grab' points on hoses and equipment would facilitate safe and efficient deck handling, especially in cold and ice-forming conditions, and particularly when handlers were wearing bulky insulated work gloves.

Also, the Juniper Class Seagoing WLB has space for temporary storage containers and one can be seen in Figure 7. A preliminary layout for four of these tanks was developed during the Deepwater Horizon Response but detailed design is needed for on-deck or below-deck mounting and appropriate plumbing for cold weather use.

Figure 7. A temporary storage container (gray tank) mid-deck on a Juniper Class Seagoing WLB.

5.1.2 DESMI Helix Skimmer: Day 2

Day 2 ice conditions were appropriate for vessel and skimmer demonstrations in sheet ice conditions. APPENDIX G provides details for this tactic. During this evolution the Hollyhock experimented applying its ice-breaking capabilities to cut channels and pockets into the ice for oil collection. Single- and multi-pass channels were created. Figure 8 shows a channel cut into the sheet ice and a side pocket running at an acute angle to the main channel. This ice-breaking effort produced an area of open water into which the skimmer was deployed. For this evolution, the vessel crane 'large block' (a 750-pound tackle block) was used to hoist and position the skimmer. Consensus was that it better facilitated controlled deployment of the skimmer vs. the 'whip crane' (125-pound ball-weighted hook). Figure 9 shows the skimmer on deck just prior to deployment. For this demonstration, a half-bale of peat moss was added to the water as an oil spill surrogate. Figure 10 shows the skimmer, deployed in an open-water pocket, and surrounded by the floating peat moss. Figure 11 provides some closer details of the deployment. The skimmer appeared to successfully recover the peat moss while ingesting a very small quantity of water. Figure 12 is an extreme close-up view of the skimmer showing an amount of recovered peat moss and small bits of ice along with minimal liquid water.

Immediately prior to skimmer recovery, the system pump was briefly reversed, purging the intake line. This reduced the overall handling weight and facilitated the crew's ability to handle and stow the system on deck.

During the second evolution of Day 2, further 'tactical' ice breaking and maneuvering of the vessel was performed to 'park' the bow into a continuous ice sheet and create a convenient open-water pocket between the vessel and the ice sheet edge. APPENDIX G provides details on slotting tactics. This maneuver created a pocket into which oil could be herded, collected, and recovered. This configuration, combined with a tugboat with fire-hose herding capabilities, demonstrated a useful and convenient collection tactic. This collaborative tactic is discussed and illustrated in more detail in Section 5.2.

Figure 8. Channel or 'slot' created in sheet ice by CGC Hollyhock to facilitate oil skimmer deployment.

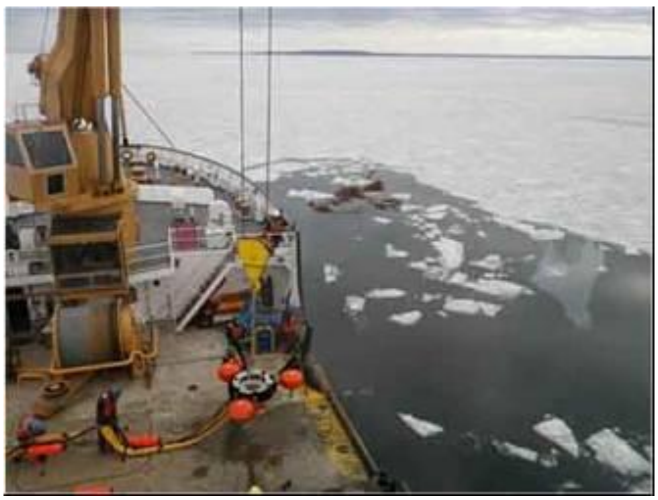

Figure 9. Helix skimmer being prepared for deployment in open water pocket surrounded by extensive ice sheet.

Figure 10. Helix skimmer deployed near ice edge by crane using 750-lb block; peat moss oil spill surrogate can be seen surrounding skimmer brushes.

Figure 11. Details of Helix skimmer in process of recovering peat moss oil spill surrogate.

Figure 12. Extreme close-up of skimmer in operation near an ice edge, showing adjacent and collected peat moss, small bits of collected ice, and minimal collected liquid water.

5.2 Fire Monitor Herding

5.2.1 Fire Monitor Herding: Day 1

Fire monitoring herding demonstrations were not scheduled for Day 1 of the demonstration.

5.2.2 Fire Monitor Herding: Day 2

A stern-mounted fire pump and hose nozzles were installed on T/V Erika Kobasic. Figure 13 shows the stern mounting position of the fire hoses. The tugboat was tasked with demonstrating a high-pressure and high-volume fire hose system that could be used to direct, localize, and concentrate spilled oil, facilitating recovery. To demonstrate technique effectiveness, floating oranges and peat moss were deployed to simulate oil targets. Once on-scene in an area with solid/brash/broken ice, a large pump was lowered down the port stern side and supplied a tri-nozzle platform secured to the stern of the tugboat. The Erika Kobasic attempted to direct streams of water at the simulated oil target and herd it into position for convenient recovery. APPENDIX G provides details for this tactic. CGC Hollyhock nosed its bow into the edge of a

solid ice sheet, creating an open water pocket between the vessel hull and the edge of the sheet ice. Figure 14 illustrates this collaboration of effort between the Hollyhock and Erika Kobasic. In that configuration, the Hollyhock was able to deploy its skimmer and attempt to collect the oil simulants directed into the pocket by the Erika Kobasic.

Figure 13. Stern-mounted fire monitor water cannon on T/V Erika Kobasic demonstrating herding ice and oil surrogate.

Figure 14. Two fire monitor water cannons on stern of T/V Erika Kobasic herding ice towards pocket in sheet ice created by CGC Hollyhock.

A case of floating oranges was placed as a target 300 yards out from the cutter/ice edge pocket. The Erika Kobasic proceeded to try an assortment of high-stream water pressure jets and directing techniques to drive the oranges to the target area. Figure 15 illustrates the Erika Kobasic herding oil surrogates towards the edge of a solid ice sheet. It was difficult to direct the oranges in a straight path because the water current tends to drive the oranges in a dispersed fan pattern rather than a straight line. The stern-mounted water cannon provided a challenge for the skipper to maneuver the tugboat because of the obstructed view from the bridge to tugboat stern.

A bag of peat moss was also dumped overboard and the water cannons again attempted to drive the floating material to the target area. The peat moss behaved more closely to an oil sheen and the water jets had better control directing this material.

Figure 15. Fire monitor water cannon on stern of T/V Erika Kobasic herding ice and oil surrogates toward collection pocket created by CGC Hollyhock and edge of ice sheet.

5.3 DESMI PyroBoom®

5.3.1 DESMI PyroBoom: Day 1

Erika Kobasic was tasked with towing a PyroBoom fire boom along with the tugboat Nickelena, through broken ice while using floating oranges as simulated oil targets. APPENDIX G provides general details for this tactic. More specific descriptions of this tactic, as specifically used in this demonstration, are given in subsequent paragraphs below. The boom was laid on the aft deck of the Nickelena and, once on-scene, the Erika took one end and slowly pulled the boom off the deck. The boom was towed at 3 knots, directly astern of the Nickelena. Figure 16 shows the boom being deployed from the stern deck of the tugboat.

Figure 16. PyroBoom in process of being deployed in rubble ice from stern of tugboat.

The first attempts were to collect only floating oranges in open water and for the tug captains to get a feel for the boom in rough seas. This evolution was generally successful. Subsequent trials incorporated ice chunks with the oranges. In the first attempt, once near an ice edge, the Nickelena slowly towed its end of the boom and attempted to break off an edge of the ice sheet and collect the resulting ice rubble in the boom pocket. Figure 17 and Figure 18 show the PyroBoom in the field of rubble ice. The first 'bite' attempted was too large and the leading end of the boom tended to ride up on the ice table. In a second attempt, several oranges were tossed into the water/ice mix, and a smaller volume of ice was successfully captured along with the floating oranges. Both tugs slowly towed their respective ends of the boom at about 1.4 knots. Seas were 2-3 ft and wind was 20 knots. Faster towing permitted the ice to ride up and over the PyroBoom. The strong cross-wind also tended to lay the boom over on a side and allowed the ice chucks to submerge beneath and escape the boom. The oranges rode in the ice mix and approximately 80 percent stayed in the boom. A third collection attempt of an ice and oranges mix was made. This time the boom was towed in a 'J' configuration with the wind generally off the tugboat port bow. Figure 19 shows the two tugboats deploying the PyroBoom in the 'J' configuration. This kept the boom contents securely inside the bite and kept the windward leg of the boom from lying over. Figure 20 shows the PyroBoom with entrained ice rubble being towed. Figure 21 is a close-up of the peat moss oil simulant as it would be encircled by the PyroBoom. Figure 22 is a close-up showing oranges employed as oil surrogates entrapped by the PyroBoom.

Figure 17. PyroBoom surrounding selected rubble ice volume.

Figure 18. Close-up of PyroBoom deployed in rubble ice.

Figure 19. PyroBoom deployed and towed by two tugboats to simulate collection of oil in rubble ice.

Figure 20. Towing the PyroBoom in a ‘U’-shaped configuration with captured ice.

Figure 21. Peat moss oil simulant in water.

Figure 22. Oranges collected in boom pocket.

Several approaches were made into the ice field using the PyroBoom in varying configurations to determine which method would be the most effective. The traditional 'U' shape did succeed in collecting some broken ice but, due to the additional maneuvering by the two tugs, much of the broken ice was lost and any actual oil collected would have been minimal. Additionally, the prop wash from the vessels could have pushed any oil at the surface farther under the ice making recovery increasingly difficult. For this demonstration, the two tugs were using 200 feet of PyroBoom.

Another method that was explored used a 'J' configuration. This method called for tugboat 1 to trail behind and outboard of tugboat 2 which would proceed ahead with the PyroBoom trailing behind as it approached the edge of the broken ice field. Figure 23 shows this configuration. Tugboat 2 would move into the ice at an angle sufficient to allow the boom to trail in the opening produced by the tugboat as it moved inboard of the oil/broken ice to allow the PyroBoom to stay in a vertical orientation and not ride up onto the ice becoming ineffective. While tugboat 2 was proceeding into the ice, tugboat 1 stayed outside the ice field in open water but paced tugboat 2, keeping a pocket in the bottom of the 'J' configuration. Slow speed maneuverability is essential for this operation; the tugs being able to effectively maneuver at 1 knot or less allowed them the fine control necessary to accomplish this. The tugs proceeded 40-50 ft into the broken ice using a total of 200 ft of PyroBoom. A slow, gradual turn towards open water commenced, allowing the PyroBoom to gradually follow the tugs maneuvering without being forced out of the ice and lying flat on its surface. The length of the boom proceeding behind tugboat 2 allowed for sufficient boom to encircle the oil/broken ice to contain the oil/broken ice as it is pulled away from the broken ice field. Tugboat 1, still paralleling tugboat 2, also commenced a pivot away but holding station from the edge of the ice in preparation for moving the collected oil/broken ice away from the main broken ice field. Figure 24 shows this maneuver. As tugboat 2 slowly cleared the edge of the ice field, tugboat 1 started to proceed forward at a speed matching tugboat 2, allowing the oil/broken ice to settle into the pocket of the PyroBoom, which at this point in the maneuver had begun to take on a classic 'U'-shaped configuration. Both tugs proceeded into open water at 1 knot to the area where the in-situ burning (ISB) would take place, as shown in Figure 25. During several attempts to use this method, it was observed that of the initial "bite" of oil and broken ice the boom took of the broken ice pack, between 70 percent and 85 percent of the initial volume stayed in the boom once the ice pack was cleared. The amount of broken ice and size of the ice pieces also was observed to play a role in the success of the boom. During the demonstration, it was observed that a broken ice field of 60-75 percent with pieces 4 ft in size or less was the overall type of ice that was being operated in. Less ice concentration with smaller pieces would improve chances of more oil collected for ISB.

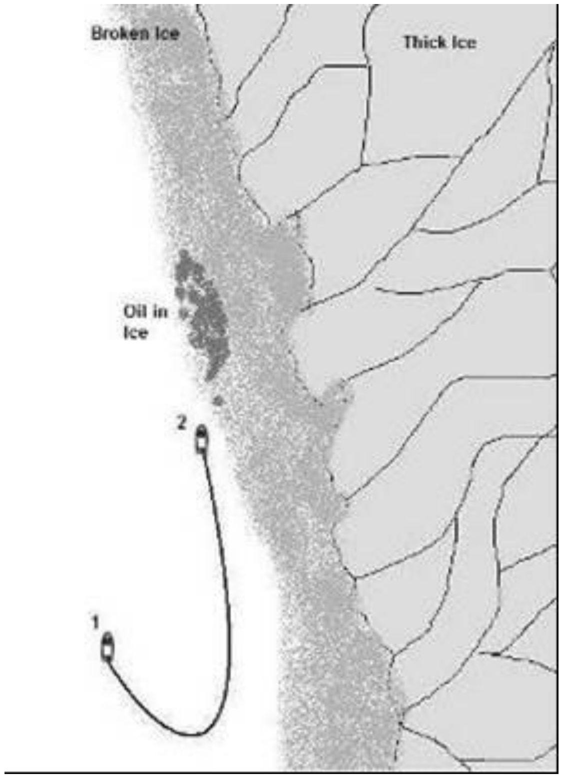

Figure 23. Initial approach to oil-saturated rubble ice field

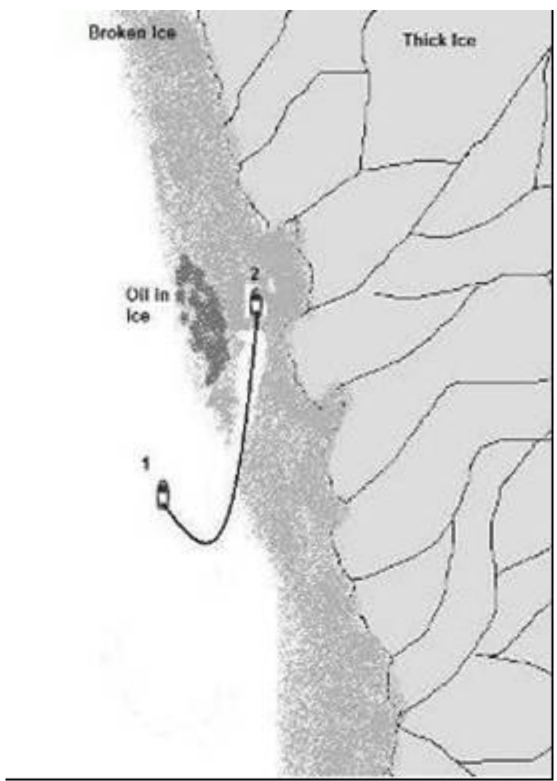

Figure 24. Maneuvering behind oil-saturated rubble ice.

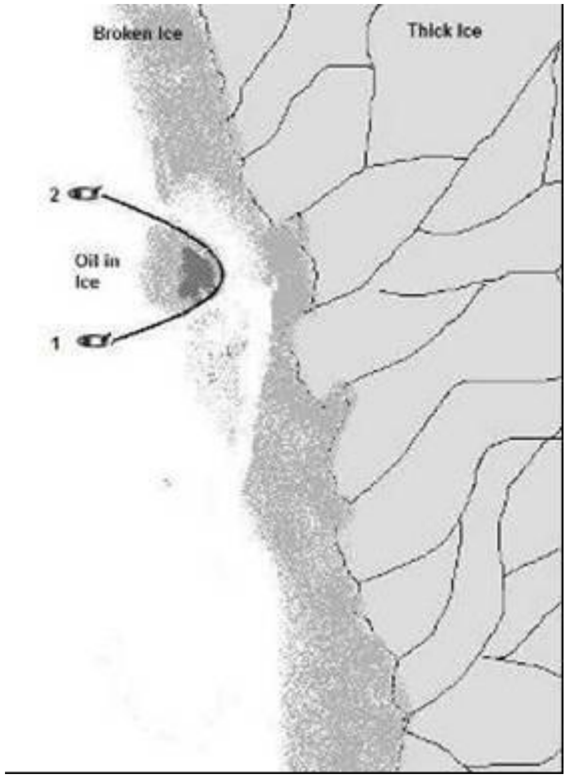

Figure 25. Maneuvering boom-captured oil-saturated ice.

During the demonstration, it was seen that certain characteristics are needed in any vessel being used for ISB in ice conditions. Good slow speed capability is a must for any vessel. Being able to have this fine detail of maneuverability allows the vessels to make fine adjustments in course and speed needed for such an operation. The slow speed operation also limits the amount of oil that could be pushed further under the ice by excessive prop wash. A bow thruster also adds to the vessel's maneuverability in ice-choked waters, giving the operator more control during the towing situations. Ice-breaking capability is a necessity for any vessel being used in this environment to ensure a safe operation; the vessel should have more ice-breaking capability than is needed for the conditions present. This will allow a safety factor, in case of changing ice conditions, to prevent the vessel from becoming trapped in the ice.

5.3.2 DESMI PyroBoom Day 2

The PyroBoom was not scheduled for deployment on the second day of the demonstration.

5.4 DESMI Polar Bear Skimmer

5.4.1 DESMI Polar Bear Skimmer: Day 1

The T/V Reliance, with Polar Bear skimmer onboard, had to anchor in the icepack to repair its gearbox oil cooling system. During those repairs, currents were moving the ice to the north too fast for an effective deployment and demonstration of the Polar Bear skimmer. Figure 26 shows the Polar Bear and associated hardware on deck of the tugboat.

Figure 26. Polar Bear Skimmer on stern deck of T/V Reliance.

5.4.2 DESMI Polar Bear Skimmer: Day 2

The Polar Bear skimmer appears to be rugged and is designed to withstand the broken ice conditions encountered on Day 2. The Polar Bear skimmer had previously been used in oil-polluted waters during some testing prior to this demonstration. After that deployment, the brushes were cleaned with kerosene. Residue from this cleaning process created a minimal but observable oil sheen when deployed. The demonstration deployment of the Polar Bear skimmer was immediately stopped. Figure 27 shows the Polar Bear in the process of being deployed via crane from the stern of the tugboat. New (oil-free) brushes should have been installed prior to the demonstration.

Figure 27. Polar Bear Skimmer deployed in open water pocket in rubble ice via crane from stern deck of T/V Reliance.

5.5 Elastec Drum Skimmer

5.5.1 Elastec Drum Skimmer: Day 1

The Elastec drum skimmer was shipped and loaded onboard the T/V Reliance with marine antifreeze in its pumps. (Figure 28) Once underway, skimmer operators wanted to pump the antifreeze into the bay. This could not be accomplished without state environmental permission. Alternatively, the antifreeze was drained into a bucket and temporarily stored onboard the tugboat. The Elastec drum skimmer pump system was frozen and had to be thawed. Once the system was running, the steam melted the surrounding ice on the deck, creating an ice-free area on the deck. With the T/V Reliance remaining at anchor in the icepack

repairing its gearbox oil cooling system, the decision was made not to attempt deployment and risk causing potential damage to the system. The Elastec system was not designed to be inserted into thick loose ice, in close physical proximity, and with contact against the side of the vessel. APPENDIX G provides details for this tactic.

Figure 28. Elastec drum skimmer on stern deck of T/V Reliance.

5.5.2 Elastec Drum Skimmer: Day 2

Initially on Day 2, the skimmer steam heating system did not appear to correctly function. It was believed that it might be due to frozen pumps, similar to that encountered on Day 1. Instead, it was determined that the pumps needed to be fully primed to remove air bubbles from the water and steam lines. Once primed, the system appeared to function properly. The system performed best in open water conditions, but when high concentrations of rubble or sheet ice were encountered, the system did not have an appropriate footprint, profile, or sufficient mass to displace the ice and develop solid contact for the drums with the water surface. Figure 29 shows the drum skimmer attempting to be deployed in a field of rubble ice. In an ice-infested environment, the skimmer did not appear to have the ruggedness necessary to survive prolonged operation in and among ice floes. In this regard, some damage to the perimeter steam tubes was noted. A thicker metal housing and guard rails would improve survivability in ice. The concept of using steam to keep the system ice-free and lowering the viscosity of the oil is a concept that has merit in ice and sub-freezing conditions. In the current configuration, the system appears to list in the water due to the weight of attached hoses and lines.

Figure 29. Elastec drum skimmer deployed in rubble ice from stern of T/V Reliance.

5.6 DESMI Rope Mop Skimmer

5.6.1 DESMI Rope Mop Skimmer: Day 1

With the T/V Reliance remaining at anchor in the icepack repairing its gearbox oil cooling system, the rope mop skimmer was the only system deployed from the T/V Reliance on Day 1 of the demonstration. The tugboat's deck crane was located on the starboard side, so did not permit deployment of the skimmers on the wind-sheltered leeward side of the vessel. The system was crane-deployed over the side of the tugboat, but the strong wind, estimated at 15-20 knots, and fast moving ice, estimated at 1-3 knots, prevented the rope mops from fully maintaining contact with the water. Figure 30 shows the rope mop being blown by strong winds and prevented from making sufficient contact with the water to be effective.

5.6.2 DESMI Rope Mop Skimmer: Day 2

The rope mop skimmer appeared to work well in the ice conditions encountered on Day 2 but, without oil/product on the water, the end of the mop tended to float on the surface until deployed and given the opportunity to saturate. Figure 31 shows the rope mop suspended in an open pool of water amidst the ice field. A hydraulic hose on the rope mop skimmer developed a pinhole leak. The system was retrieved on deck and the hydraulic hose was replaced. Afterwards, the system was returned to the water and was observed to pick up some of the peat moss oil spill surrogate.

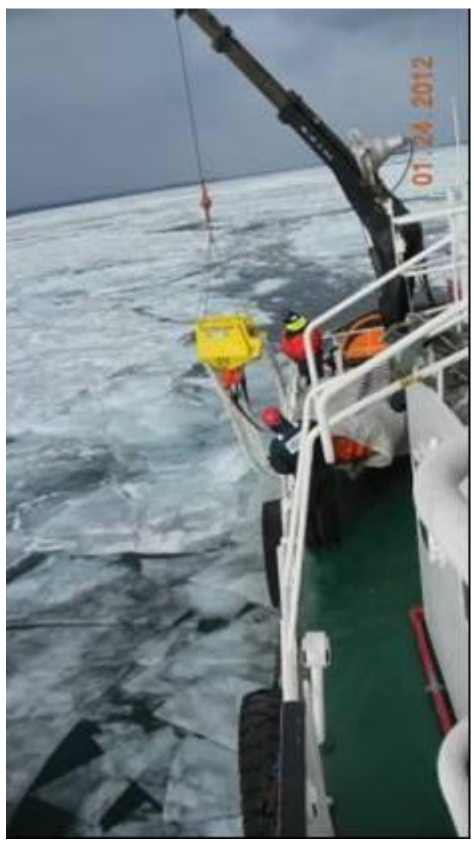

Figure 30. Rope mop skimmer being blown out of the water on Day 1 of the demonstration.

Figure 31. Rope mop skimmer deployed in open water pocket from T/V Reliance on Day 2 of the demonstration.

5.7 Deep Ocean HD2 ROV

5.7.1 Deep Ocean HD2 ROV: Day 1

The ROV was not scheduled for deployment on Day 1 of the demonstration.

5.7.2 Deep Ocean HD2 ROV: Day 2

The ROV was deployed by hand from the deck of T/V Nickelena near the ice edge. Figure 32 and Figure 33, respectively, show the ROV control cables and ROV on the deck of the tugboat. APPENDIX G provides details for this tactic. To increase safety during ROV deployment and recovery, using the tugboat's crane should be considered. This would be especially helpful under rough weather conditions. Set-up and deployment of the ROV requires a clear deck space. It is recommended that the main propulsion of the host vessel be shut down to prevent the ROV tether and control cable from becoming fouled in the propeller. Figure 34 shows the ROV deployed in the ice-infested water.

The ROV was deployed under the ice out to about 50 feet away from the vessel. Using the camera, the bottom of the ice could be clearly seen. A light was available for use when thicker ice is present or during darkness. The laser fluorometer that was mounted on the top of the ROV pointing upwards, was overloaded by the sunlight when at a depth of less than 10 feet. Once past this depth, the sunlight was filtered out enough for the sensor to detect the reflection of the laser. Additional sensors such as upward –looking sonar or more powerful cameras are available.

There appears to be great potential for a sensor-equipped ROV for oil spill detection under the ice. Combining visual along with the laser fluorometer would provide a better picture of the extent of oil under the ice. The potential for using an ROV to deploy oil recovery equipment under the ice became apparent during the demonstration.

Figure 32. ROV control cables on deck of T/V Nickelena.

Figure 33. ROV on deck of T/V Nickelena.

Figure 34. ROV deployed from T/V Nickelena in water pocket near ice sheet edge.

6 LESSONS LEARNED AND OBSERVATIONS

There were multiple comments from all of the participants about what was seen and what other issues still need to be resolved. These were recorded by RDC and SAIC personnel during the demonstration, as well as during quick hot-wash meetings held at the end of each day and at a summary meeting the last day. Some of these cover more than one area so may appear in more than one of the categories below. Many of these observations are not new to personnel who routinely respond in cold weather but since this type of response is relatively rare, additional efforts are needed to pass these on to all potential planners and responders.

6.1 Planning

- Monthly or bi-weekly teleconferences with principal players are key to communications and coordination.
- In-person meetings with principle players early in the planning process and just prior to deployment facilitate team building, cooperation, collaboration, and communications.
- The unexpected can occur and often does. Be prepared.
- Confirm scheduling of delivery and arrival of equipment and assets.
- Ensure flexibility of service contracts to allow for impacts of changing weather, ice conditions, equipment availability, and equipment failures.
- Ensure vessel captains are involved in operational meetings.

6.2 Logistics

- Load-out
  - Prepare for environmental infrastructure safety issues; e.g., ice-coated surfaces of pier for morning of load-out.
  - Ensure heaving lifting capability and reach for loading response gear.
  - Stage from pier area with enough support for crane, forklift, and oil recovery equipment.
  - Ensure pier and moorings have sufficient water depth to support deep draft vessels.
  - Prior to arrival, all equipment should be made cold weather ready (water removed from hoses, cold weather lubrication).
  - Upon arrival, ensure that pallets or shipping packages are in good order (pallet broke during shipping process, difficult to remove contents after they fell out of the truck).
  - Schedule arrivals of equipment to prevent bottlenecking on the pier.
  - Be aware of local assets that can be brought into play if needed.
- End-of-Mission
  - All considerations made for load-out apply to end-of-mission.
  - All systems should be purged of water prior to storage to prevent freeze-up.
  - Provisions needed for hazardous material (HAZMAT) decontamination, disposal, and clean-up of recovery equipment.
  - Holding a ‘hot wash’ on the final day of the demonstration permits discussion and recording of issues and lessons learned while still fresh in the minds of participants.

6.3 Equipment

- Helix skimmer
  - Exposed fittings, couplings, hoses, and mechanical components should be better armored to protect system from damage by rubble ice.
  - Consider armored hoses and hydraulic line sections where direct contact with rubble ice may cause puncture or severing.
- PyroBoom
  - Boom appeared to hold up well while gathering and towing ice.
  - Close coordination between both vessels is important to successful deployment of PyroBoom into the ice.
  - Two vessels of sufficient horsepower with ice-breaking capability are required for effective deployment and manipulation of the boom.
  - Boom can be deployed by allowing it to slide off the vessel deck, or it can be deployed in sections if the vessel has an onboard crane.
  - Forty to fifty percent broken ice coverage with floes no larger than 1.5 meters appears to be the limit for carving out a sufficient oil/ice mixture for in-situ burn.
  - Thicker concentrations of broken ice and larger floes caused PyroBoom to override the ice.
  - Use of a ‘J’ formation rather than the straight ‘U’ with a boom appears to make it easier for the vessels to control the amount of ice captured.
- Polar Bear skimmer
  - Systems with oleophilic components such as brushes and rope mops should be ensured to be totally oil-free prior to deployment in practice drills and demonstrations to prevent dispersal of even small quantities of product in the environment.
  - A safety concern with this skimmer was that personnel needed to climb on top of its frame to complete connections, which could be hazardous in icy conditions.

- Drum skimmer
  - Drum skimmer may be too light to properly settle into a field of rubble ice and efficiently function.
  - The drum skimmer may not be sufficiently armored for use in heavy rubble ice conditions.
- Rope mop
  - Deploying the rope mop in high winds is difficult and possibly results in suboptimal performance due to 'sail effect' deflecting the exposed portion of the mop belt.
  - The rope mops should have a breakaway device or weak-link point to prevent the system from being damaged or pulled into the water if a rope mop gets hung up on a large piece of ice.
  - The rope mops can get tangled and untangling them safely and quickly is important.
- ROV
  - ROVs require a clear deck area for safe and timely assembly and deployment.
  - The main propulsion on the vessel from which the ROV is operating should be shut down to prevent cable entanglement in the vessel prop.
  - ROV can be deployed and recovered without a crane; crane would be added safety in rough conditions.
  - There is great potential for oil spill detection under the ice using an ROV with laser fluorometer mounted onboard. Additional work needs to be done on fluorometer by the vendor to look up into daylight at shallow depths.
  - ROV allows visualization of oil under the ice and, when combined with detection sensors, gives a better picture of the extent of the oil under the ice.
  - There is a potential application of an ROV with built-in capability to recover oil from under ice.
- Herding
  - Bow-mounting of fire hoses simplifies communications from the hose operators and the vessel driver and provides the ability to more effectively navigate the boat and drive the oil in the desired direction.
  - Lower attack angle from water streams may improve herding ability.
  - Water pressure cannons were insufficient to move large ice floes but could be used to wash oil off ice.
  - CG cutter thrusters and prop wash interfered with herding efforts when vessels are operating nearby.
  - Various spray patterns from the hose nozzle and coordination between multiple water cannon tactics should be explored.

6.4 Tactics

- Oil surrogates (peat moss and oranges)
  - In general, the use of limited quantities of oranges and peat moss, environmentally benign oil spill simulants, were useful in visually demonstrating the effects/results of the various oil recovery techniques and tactics demonstration.
- Oleophilic brushes and rope mops do not collect peat moss as they would attract and collect oil.
- Any herding should have the fire monitor mounted on the bow for easier control and maneuvering.
- Lighter or vulnerable skimmers cannot be placed near ice and be expected to stay intact. Extra structure for protection of vulnerable links is needed for tough conditions. The location of the operator should also be considered for safety.
- Weather conditions in the Great Lakes may cause circulation patterns that cause the ice to move in a different direction than the wind. Planners and responders should be aware and if possible collect drifting information using other methods (e.g., buoys).

- An ice-capable vessel can utilize slotting tactics adapted from solid ice techniques if the ice mass is relatively stable. Changes in direction of wind and current must be monitored and adjustments made as needed.

6.5 Vessel Specific

- Vessels with large deck area and of sufficient horsepower are needed.
- The temporary storage tanks appear to be useful for WLB. Additional work will be needed for design and use of a manifold.
- Juniper Class WLB have better capabilities than most commercial vessels that could serve as a vessel of opportunity.
- Number of people that can be placed on tugs is limited due to safety and vessel's toilet facility capacity.
- Use of foreign flag vessels is possible but brings unique issues (Customs, Immigration, "Jones Act," etc.). Agreements that cover actual responses may not be in effect for demonstrations.
- Only vessels with the ice hardened capabilities of a CG buoy tender of the Keeper Class Coastal Buoy Tender (WLM), or greater, could operate in this type of environment. Few other vessels with similar characteristics currently operate in the Great Lakes. The CG 140' Bay Class icebreaking tugboats (WTGBs) have capabilities to operate in the ice and the 65' Inland Buoy Tenders have limited capability.Use of tugs, which have infinite speed control, for fire boom is better than vessels which have to clutch in and out to maintain a 1 knot speed.
- It is not clear if tugs could also handle the temporary storage system designed for CGC Hollyhock and could have problems with other types as well. Some may be able to handle 1-2 tanks and may be adequate if the expected encounter rate is low.
- All vessels, except CGC Hollyhock, would have difficulty in handling crew decontamination during an actual spill. A structure would be needed on deck as a warm zone to disrobe from the personal protective equipment (PPE) to ensure oil is not tracked into the other spaces.
- Most tugs only have crane sized to handle a small boat and may not be able to deploy large systems, especially the hydraulic power units normally used.

6.6 General Observations (Not Elsewhere Addressed)

- Zip-ties used to secure hoses break in cold temperatures; appropriate low-temperature hardware and 'winterized' equipment is necessary.
- Seamanship skills and experience in ice navigation/piloting significantly impact success of oil recovery.
- Take appropriate measures to prevent hose and mechanical freeze-up of equipment upon end of deployment or end of day.
- Physical activity is more difficult/hazardous under extreme weather conditions.
- Required protective clothing restricts physical movement and hampers communications.
- Many items normally done during a spill cannot be done during a demonstration. For example, cars and a Government vehicle that blocked a loading ramp would have been moved to facilitate loading during an actual spill.
- An approved process should be in place for leaving non-operating equipment exposed for long periods of time during cold weather. This may also be needed if operations are stopped periodically and restarted in subfreezing temperatures.
- Extra parts for all components should be provided due to weather and lack of support. This includes hoses, O-rings, and any disposable pieces (e.g., sorbents, nuts, bolts, and shackles).

- Provide warming tent and Safety representative for each staging area to improve communications and overall safety during demonstrations.
- Ensure local charts are posted, marked, and used during briefs to improve awareness and safety.
- A mix of Coast Guard, Enbridge Pipeline, oil recovery contractors, DRAT, and SAIC personnel aboard each vessel proved invaluable with respect to operational consensus and feedback.
- Contractual provisions should be considered in case of a need for 'after-hours' support from heavy equipment and associated equipment operators.
- Contracts for services, vessels, and heavy equipment should be flexibly written to consider contingencies such as 'weather days' and partial days of operation.
- Vessels selected for use should have a small crane capable of deploying the lighter equipment during a spill.
- Collaboration and shared experience among CG, CG RDC, contractors, and equipment vendors provided valuable lessons learned, procedural and tactical technique adaptations and improvements, and potential equipment modifications to meet specific challenges of operation in extreme cold environment and ice-infested waters.
- Prior training of equipment-handling personnel and vessel operators is critical to safe and efficient operation.
- Different recovery systems and tactics necessary for different ice and weather conditions should be available.

7 RECOMMENDATIONS

- For large demonstrations, approach planning more like an actual response to ensure continuity and safety.
- CG and OSROs should utilize skimmers that do not collect a large amount of water in order to minimize storage requirements under cold-weather conditions.
- Heavy duty booms that can collect oil and ice for mechanical collection should be identified and evaluated. If nothing exists, a specification should be developed.
- Prior to any future demonstrations, ensure that equipment suppliers have adequately cleaned their equipment since the last test or deployment. If not clean, a sorbent boom should be deployed in a ring, as a precaution, before launching any skimmers.
- If funding permits, spill response subject matter expert (SME) support should be provided to D17 during a planned deployment north of the Arctic Circle in the summer of 2012. Demonstration of the Polar Bear skimmer (use Helix if not available) in this deployment is also recommended.
- Consideration for a demonstration that includes more decision-making should be considered for FY13 in the Great Lakes. Additional time should be planned for considering training and then placing target surrogates; and then letting the responders determine the response tactics, as would happen in an actual spill.
  - Ensure appropriate offices within D9 are involved in the planning and execution for the next demonstration to allow the opportunity to stand up portions of an ICS for at least Operations and Planning to ensure safety.
  - Although a safety section was included in the test plan, a Site Safety Plan (SSP) should be further developed.
  - A more definitive communications plan should be written and implemented. Vessel and aircraft communications capabilities should also be checked to ensure compatibility.

  - Minimal ICS forms should be used to describe objectives better during demonstrations. A limited Incident Action Plan (IAP), and form ICS-204 would have provided better direction.
- Recommend additional demonstrations under extreme Arctic conditions will further improve and build upon lessons learned, operational and tactical protocols, and equipment deployment, application, and design.
- Consider involving more CG assets if available to provide more exposure to additional personnel about issues of responding to spills in ice.
- Additional sensors should be considered for finding oil that is under the ice. RDC should work with Oil Spill Recovery Institute out of Cordova. AK which recently performed some tests at the U.S. Army Corps Cold Region Research and Engineering Laboratory (CRREL) as well as on-going industry efforts.

8 SUMMARY

The objective of this demonstration was successfully achieved by deploying multiple pieces of equipment and exercising various tactics that could be used to recover oil in ice-infested waters. The actual implementation of various tactics requires some responder experience to ensure they can be done safely. A knowledge base has now been initiated for CG and commercial responders in the Great Lakes that increases the spill response capability in this region; and also provides input for the CG D17 when considering options in their own area. The competence of the vessel crews and responders were critical to the success of this demonstration

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APPENDIX A. OIL RECOVERY SYSTEMS

A.1 Spilled Oil Recovery System (SORS)

The USCG SORS is a modern, high performance, over-the-side, single-ship recovery system, designed to be used on a WLB. The SORS comprises two identical sweeping and skimming systems. The Standard Operating Procedure (SOP) is to deploy one system over one side of the vessel and deploy a temporary storage bladder over the other side. The SORS is packaged in four stackable aluminum storage/deployment containers, which fit into the hold below the WLB's main deck. The SORS is designed to be installed and operated by the vessel crew with minimal training; however, regular training on the equipment is highly recommended to improve response time and oil recovery efficiency. A crew of 10 can install the SORS equipment during transit in less than 1 hour with assistance of a lifting crane. Once on the scene, the equipment can be fully deployed and recovering oil in less than 1 hour.

Each SORS consists of two each of the following components.

- DESMI Terminator weir skimmer
- SORS control stand
- Hydraulic hoses
- Outrigger arm (not being deployed for this demonstration)
- Fast sweep boom (not being deployed for this demonstration)
- Canflex bladders (not being deployed for this demonstration)

A.1.1 DESMI Terminator

The Terminator (Figure A-1) is a high efficiency weir skimmer that can recover all types of oil, from diesel and light grade of oil to the most heavy weathered crude and emulsions. The Terminator is a positive displacement screw pump installed in the skimmer; it can pump water and high viscosity oil at the same high capacity and will not emulsify the two during pumping, making separation and decanting possible. The skimmer pump is fitted with cutting knives to process debris, including vegetation, seaweed, kelp, garbage, plastics, synthetic and natural fiber line, aluminum cans, bottles, drift wood, dead fish, birds, and small mammals. The pump can pass solids up to 2.0 inches in diameter. If the pump is clogged by debris, the operator can reverse the pump to expel the blockage using the SORS control stand.

A.1.2 Helix Skimmer

The Helix circular brush skimmer (Figure A-2) permits the oil to flow freely onto the brushes from any angle. Typically, brush skimmers work well with heavy and thick oils that do not flow. According to product documents, the large area of brushes is in contact with the oil layer for over 13 linear feet. A hydraulic motor provides power to rotate the brushes. The motor is mounted with a gearbox and a vertical positive displacement pump with a flow rate up to 125 cubic meters per hour (550 gallons per minute (gpm)) and can develop up to 10 bar (140 pounds per square inch (psi)) discharge pressure according to product documents.

Figure A-1. DESMI Terminator skimmer.

Figure A-2. Helix skimmer.

A.1.3 SORS Control Stand

The SORS control stand (Figure A-3) provides easy-to-use controls and flow meter for operating the Terminator skimmers. Hydraulic power is supplied from the hydraulic power unit (HPU) installed on the WLB. Hydraulic power can also be supplied from a portable HPU supplied from USCG Strike Force or contractor inventory if needed. The 150-pound (lb) skimmer control panel mounts on an aluminum base to raise it to a comfortable operating level. The control panel includes a skimmer control, hydraulic system pressure gage, and an electric flow meter to indicate skimming pumping rate.

Figure A-3. SORS control stand.

A.1.4 Temporary Storage Tank

The CGC Hollyhock has the capability for deck-mounting up to four 100-barrel temporary storage tanks (APPENDIX C) for attachment to a skimmer apparatus. For demonstration purposes of this demonstration, a single 100-barrel tank was deck-mounted.

A.2 PyroBoom

PyroBoom, manufactured by Applied Fabric Technologies, Inc., is a flexible oil boom (Figure A-4) made from a proprietary Inconel/Fiberfrax® refractory fabric with a silicone coating that can withstand temperatures up to 2400 °F. Stainless steel floats filled with glass foam provide flotation. PyroBoom is available in 50-ft sections and weighs about 9 pounds per foot. Table A-1 provides weights and physical dimensions for a containerized 250-foot section of boom and supporting accessories.

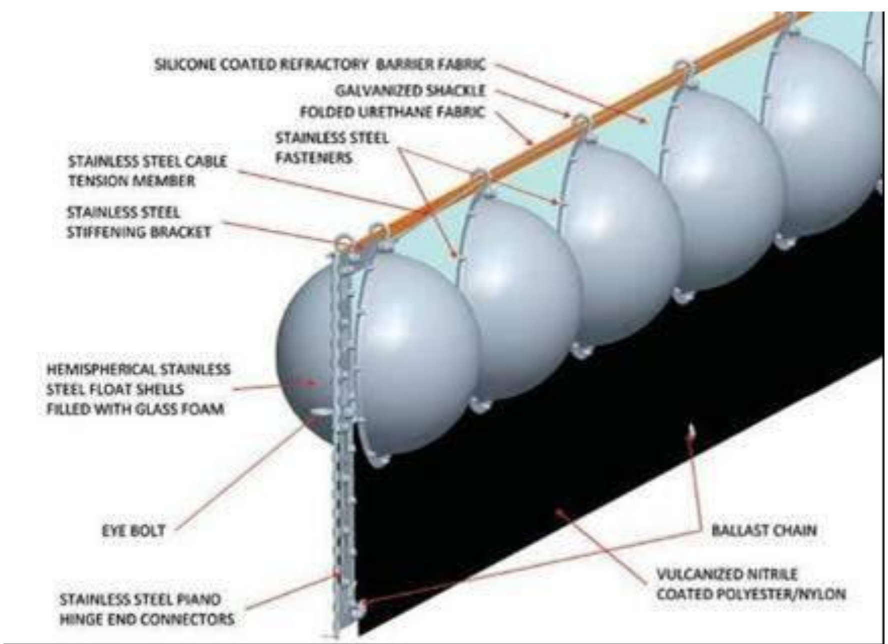

Figure A-4. PyroBoom fireproof oil boom.

Table A-1. Weights and physical dimensions for a containerized 250-foot section of boom and supporting accessories.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
250' PyroBoom and accessories in wire cage	5650 lb	115" x 86" x 99"

A.3 Heated Drum Skimmer

Drum skimmers (Figure A-5) such as those manufactured by Elastec (http://www.irismal.com/elastec.htm) can be equipped with a steam heating system for cold environments. Steam coils can be installed in the collection trough and sump, with steam heat provided by a generator housed in a separate trailer. The heat from the steam helps the skimmer to function by melting the snow and ice surrounding the skimmer, allowing the oil to flow onto the collection drums. It also warms the oil as it is recovered, aiding the flow to the transfer pump and preventing the transfer hoses from freezing. The steam generator is packaged with a water tank and pump in a custom trailer for ease of transport to the spill site, or the coils can be fed by other heat sources. Table A-2 provides physical dimensions and weights of the Elastec drum skimmer and supporting components.

Figure A-5. Steam-heated drum skimmer.

Table A-2. Physical dimensions and weights of components of the Elastec drum skimmer and supporting components.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
Magnum 100 Drum Skimmer	125 lb	70" x 57" x 18"
Hydraulic Power Unit	610 lb	50" x 43" x 41"
Hose Kit and Pump	320 lb	42" x 42" x 21"
Steam Trailer	2,500 lb	144" x 81" x 96"

A.4 Ice Herding

A demonstration of herding with a fire monitor on the water surface was conducted during this demonstration. The fire monitor consists of a self-contained Hale firefighting pump and John Deere diesel powerpack with an 8-hour operation fuel tank (Figure A-6). The fire monitor is capable of pumping up to 1500 gpm water and is foam capable. The fire monitor package, weighing 3450 lb, can be deployed on a tugboat using a barge-mounted crane. Once in position, the fire monitor may be powered up and a stream of water, 20-50 ft long, can be sprayed onto the water's surface resulting in visible water currents being directed towards the boom (Figure A-7).

Figure A-6. Fire monitor.

Figure A-7. Fire monitor in use.

This technique has been used previously in open (ice-free) water environments to aid in collecting oil. The demonstration explored using this technique in an ice-covered or partially ice-covered waterway situation. This method moved the surface oil towards containment or skimmers from a floating or fixed location. An additional use is to aid in the movement of broken ice on the water surface, keeping the ice from interfering in oil recovery operations.

One drawback to the fire monitor pack is its 3450-lb weight, which limits it to larger vessels and requires a crane to maneuver the package. Fire monitors and hoses already installed on vessels could be used in place of this fire monitor pack and should generate similar results. Any vessel using such a system would require adequate displacement to counter the thrust imposed by the water stream. Table A-3 provides dimensions and weights of fire monitor components.

Table A-3. Dimensions and weights of fire monitor components.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
LMF 135 Diesel Hydraulic Powerpack	2,850 lb	95” x 40” x 65”
KMA 333 Pump with 50’ to 100’ Discharge Hose	200 lb	29” x 12” dia.
Hose Basket	~1,000 lb	48” x 48” x 56”
3-Turret Fire Monitor	800 lb	Approx. 58” Cube in closed position

A.5 Rope Mop Skimmer

Rope mop oil skimmers (Figure A-8) recover floating oil from the surface of water using a rope mop. The “rope” is made up of an oleophilic fibrillated polypropylene material. The rope is driven over the surface of the oil by a drive unit which also squeezes the oil out of the rope and into a recovery tank. The rope mop system is capable of recovering a wide range of viscosities of oil over small or large areas, in separators or pits, harbors, and dams under a wide range of climatic conditions. Table A-4 provides weights and physical dimensions of the rope mop skimmer and supporting components.

Figure A-8. “Foxtail” rope mop skimmer.

Table A-4. Weights and physical dimensions for SEAMOP rope mop skimmer and supporting components.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
SEAMOP Rope Mop Skimmer	2535 lb	60" x 47" x 51"
SEAMOP Reel	480 lb	47" x 37" x 51"
Power Pack	3650 lb	99" x 40" x 58"

A.6 Polar Bear Skimmer

The Polar Bear Skimmer is a newly designed system developed by DESMI Ro-Clean based on tests in a tank in Norway. The system consists of a dedicated reel for the hydraulic and off-load hoses weighing 5650 pounds, a hydraulic power unit (weighing 3650 pounds), and the skimmer itself weighing 1650 pounds. Figure A-9 and Figure A-10 show the Polar Bear skimmer with supporting reel and crane, and skimmer power pack, respectively. Table A-5 provides the physical dimensions and weight of the Polar Bear skimmer and support components.

Figure A-9. Polar Bear skimmer (left) and associated reel with crane (right).

Figure A-10. Polar Bear skimmer power pack.

Table A-5. Polar Bear skimmer and support components weights and physical dimensions.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
Polar Bear Skimmer	1,654 lb	7'5" x 8'2" x 6'1"
Polar Bear Reel with Crane	5900 lb	89" x 87" x 91"
Skimmer Power Pack	3650 lb	99" x 40" x 58"

A.7 Phantom ROV with Laser Fluorometer

The Deep Ocean HD2 ROV used is 55 inches long by 27 inches wide and 26.5 inches high and weighs 190 pounds. A standard length of 2100 feet of umbilical tether weighs 695 pounds in air but is neutral in the water. Figure A-11 shows the HD2 ROV.

Figure A-11. Deep Ocean HD2 ROV.

The laser fluorometer (FL) mounted on the top is about 1-foot long and weighs about 10 pounds. It operates similar to other fluorometers that use light to cause the oil to fluoresce at specific frequencies. The intensity and frequency of the returned fluorescence provides information about the amount and type of oil. In clear water, this system can send and receive a signal several meters away. Figure A-12 shows the laser fluorometer that is attached to the Deep Ocean HD2 ROV. Table A-6 provides weights and physical dimensions for the ROV, fluorometer, and supporting components.

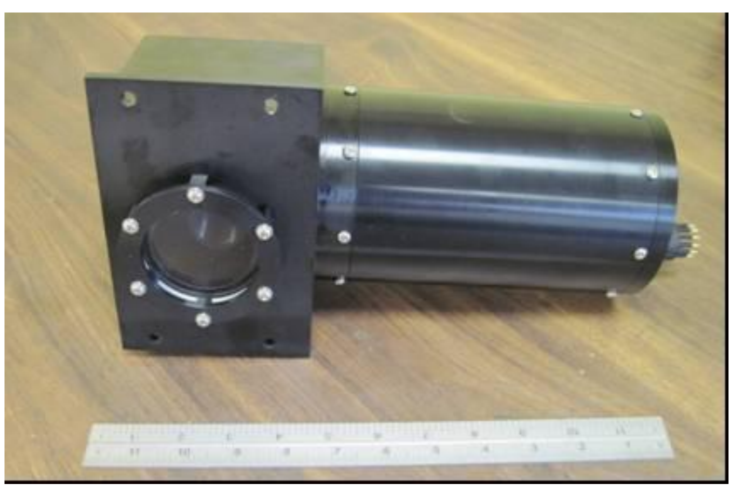

Figure A-12. Laser fluorometer.

Table A-6. Weights and physical dimensions for the ROV, fluorometer, and supporting components.

Equipment Model	Weight (Wet)	Deck Footprint and Height (L/W/H)
Deep Ocean HD2 outfitted with underwater camera/lights and laser fluorometer sensor	332 lb (w/case) 190 lb (deployed)	60” x 36” x 35” (case)
Tether for ROV 2,250’	695 lb	58” x 48” x 32”
Control Station for ROV	Minimal	4’ or 6’ long table containing console 26” x 26” x 36”
Laser Fluorometer Sensor	10 lb	~12” long
Computer Display for Laser Fluorometer Sensor	Minimal	N/A

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APPENDIX B. MANUFACTURERS' EQUIPMENT LITERATURE

Literature and brochures for the specific equipment used in this demonstration are available at the following manufacturers' websites.

- **Elastec Drum Skimmer:** http://www.elastec.com/oilspill/oildrumskimmers/drums/
- **Elastec Drum Skimmer Steam System:** http://www.elastec.com/oilspill/oildrumskimmers/steam/
- **DESMI Helix skimmer:** http://www.desmi.com/UserFiles/file/oil%20spill%20response/e-leaflet/05-15%20HELIX%20SKIMMER.pdf
- **DESMI Polar Bear Skimmer:** http://www.desmi.com/UserFiles/file/oil%20spill%20response/e-leaflet/POLAR%20BEAR-UK.pdf
- **DESMI PyroBoom:** http://www.desmi.com/UserFiles/file/oil%20spill%20response/Product%20brochure/PyroBoom.pdf
- **Deep Ocean HD2 ROV:** http://www.divetechltd.ca/hd2.pdf
- **DESMI SEAMOP Rope Mop Skimmer:** http://www.desmi.com/UserFiles/file/oil%20spill%20response/e-leaflet/05-10%20SEAMOP-UK.pdf

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APPENDIX C. PARTICIPATING VESSEL SPECIFICATIONS

C.1 CGC Hollyhock and Full Tank Arrangement

Figure C-1. CGC Hollyhock.

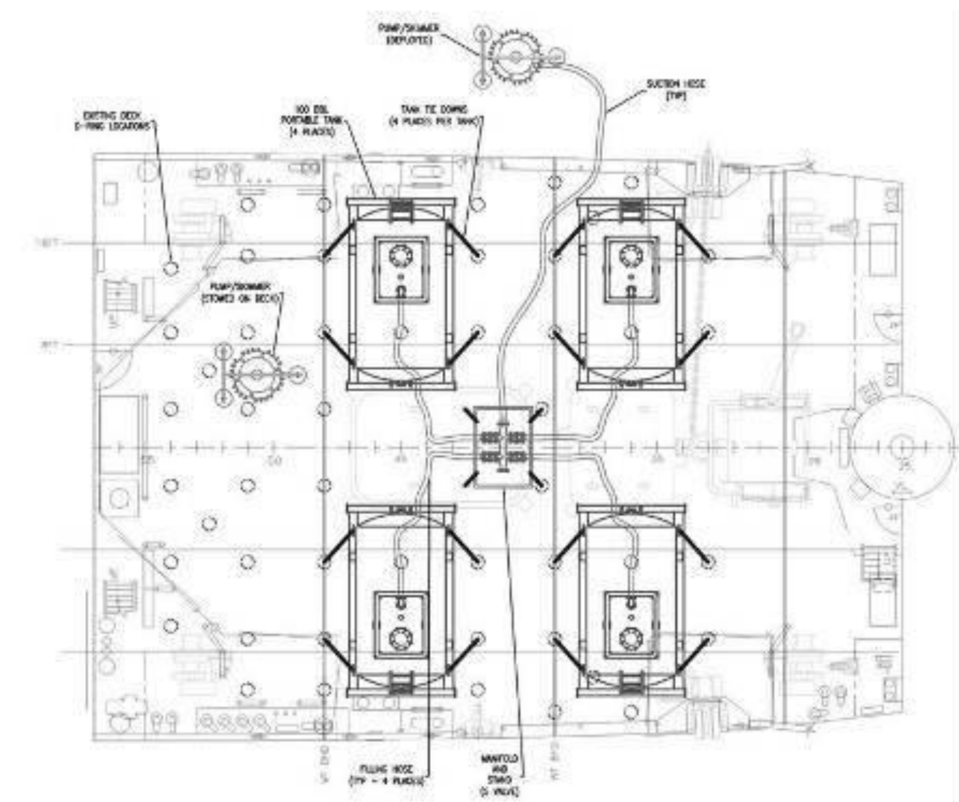

Figure C-2. WLB proposed full tank arrangement.

C.2 Tug Reliance (Canadian Registry)

Figure C-3. Tug Reliance.

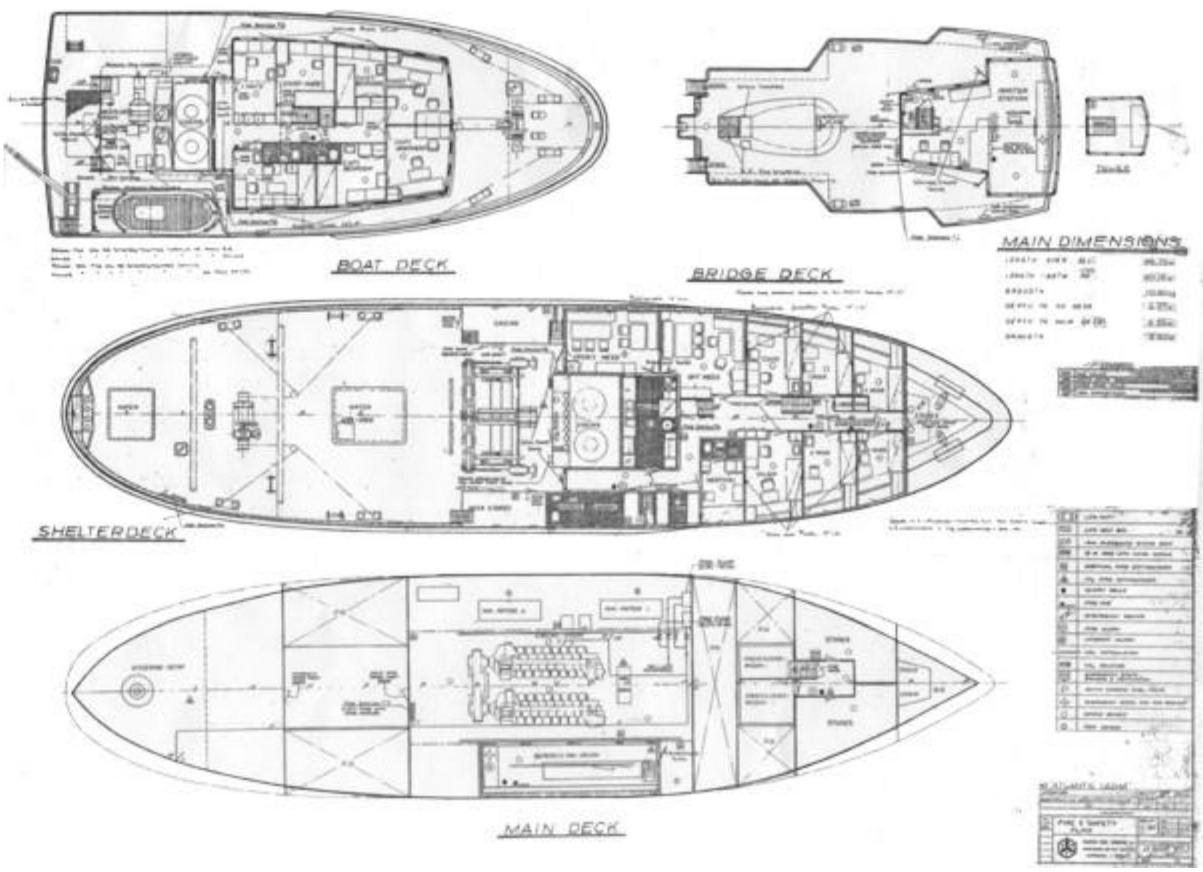

Figure C-4. T/V Reliance: deck plan.

Vessel Particulars:

Length:	203 ft
Beam:	40 ft
Draught:	23 ft
Gross Tons:	708
Call Sign:	VOSV
IMO*:	7393808
Speed:	15 knots
Flag:	CA
Built:	1974

*International Maritime Organization

Other Features:

- Crane, approximately rated for 3,000 lb capable of deploying equipment from the deck to the water
- Anchoring capability and Global Positioning System (GPS) to maintain position
- Tugboat has Automatic Identification System (AIS)

C.3 T/V Erika Kobasic (U.S. Registry)

Figure C-5. T/V Erika Kobasic.

Vessel Particulars:

Length:	110 ft
Beam:	25 ft
Draught:	12 ft
Gross Tons:	226
Call Sign:	WCO3652
Horse Power:	2000
Flag:	U.S.
Built;	1939
Propulsion:	“infinite” variable drive with bow thrusters

Other Features:

- Crane, approximately rated for 3,000 lb capable of deploying equipment from the deck to the water
- Anchoring capability and GPS to maintain position
- Tugboat has AIS

Tugboat company web page: http://www.basicmarine.com/transportation/

C.4 T/V Nickelena (U.S. Registry)

Figure C-6. T/V Nickelena.

Vessel Particulars:

Length:	108 ft
Beam:	29 ft
Draught:	14 ft
Gross Tons:	199
Call Sign:	WDER746
Horsepower	2000
Flag:	U.S.
Propulsion:	“infinite” variable drive with bow thrusters

Other features:

- Crane, approximately rated for 3,000 lb capable of deploying equipment from the deck to the water
- Anchoring capability and GPS to maintain position
- Tugboat has AIS

Tugboat company web page: http://www.basicmarine.com/transportation/

APPENDIX D. DEMONSTRATION PARTICIPANTS

Table D-1. Demonstration participants.

Name	Agency	Email Address
State/Local Representatives		
Christopher Conn	Michigan Department of Environmental Quality Water Resources	connc@michigan.gov
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Table D-1. Demonstration participants (Continued).

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Canadian Government		
N/A		

Table D-1. Demonstration participants (Continued).

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Peter Lane	Applied Fabric	lane@afti.com
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Randy Wilberg	Enbridge	randy.wilberg@enbridge.com

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APPENDIX E. ENVIRONMENTAL PERMISSION LETTER

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

RICK SNYDER
GOVERNOR

DEQ

DAN WYANT
DIRECTOR

December 8, 2011

Kurt A. Hansen, P.E.
U.S. Coast Guard Acquisition Directorate Research & Development Center
1 Chelsea Street
New London, Connecticut 06320

Dear Mr. Hansen:

Enclosed please find the Michigan Department of Environmental Quality (MDEQ) Certification of Approval issued pursuant to Rule 97 of Michigan's Water Quality Standards, authorizing your December 1, 2011, request to place small amounts of oranges and peat moss into the Mackinac Straits between January 14, 2012, and February 5, 2012. The operation is intended to model oil spill response.

The MDEQ authorization is contingent upon the U.S. Coast Guard complying with specific procedural and reporting requirements described by the enclosed Rule 97 Certification. Please review carefully the conditions of the Certification of Approval prior to commencing the operation.

Please contact me if further assistance or information is needed.

Sincerely,

William F. Dimond, Aquatic Biology Specialist
Surface Water Assessment Section
Water Resources Division
517-241-9565

Enclosure
cc/enc: Mr. Dennis Bush/Rule 97 File, MDEQ

CONSTITUTION HALL • 525 WEST ALLEGAN STREET • P.O. BOX 30473 • LANSING, MICHIGAN 48909-7973
www.michigan.gov/deq • (800) 662-9278

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APPENDIX F. LOCAL AREA MAPS AND SATELLITE IMAGES

F.1 Overall Operating Area

The demonstrations are conducted at St. Ignace, Michigan. Figure F-2 below depicts the geography of the general operating areas.

F.2 Eastern Upper Peninsula

Figure F-1 depicts the eastern portion of Michigan's upper peninsula including Sault Ste. Marie and St. Ignace.

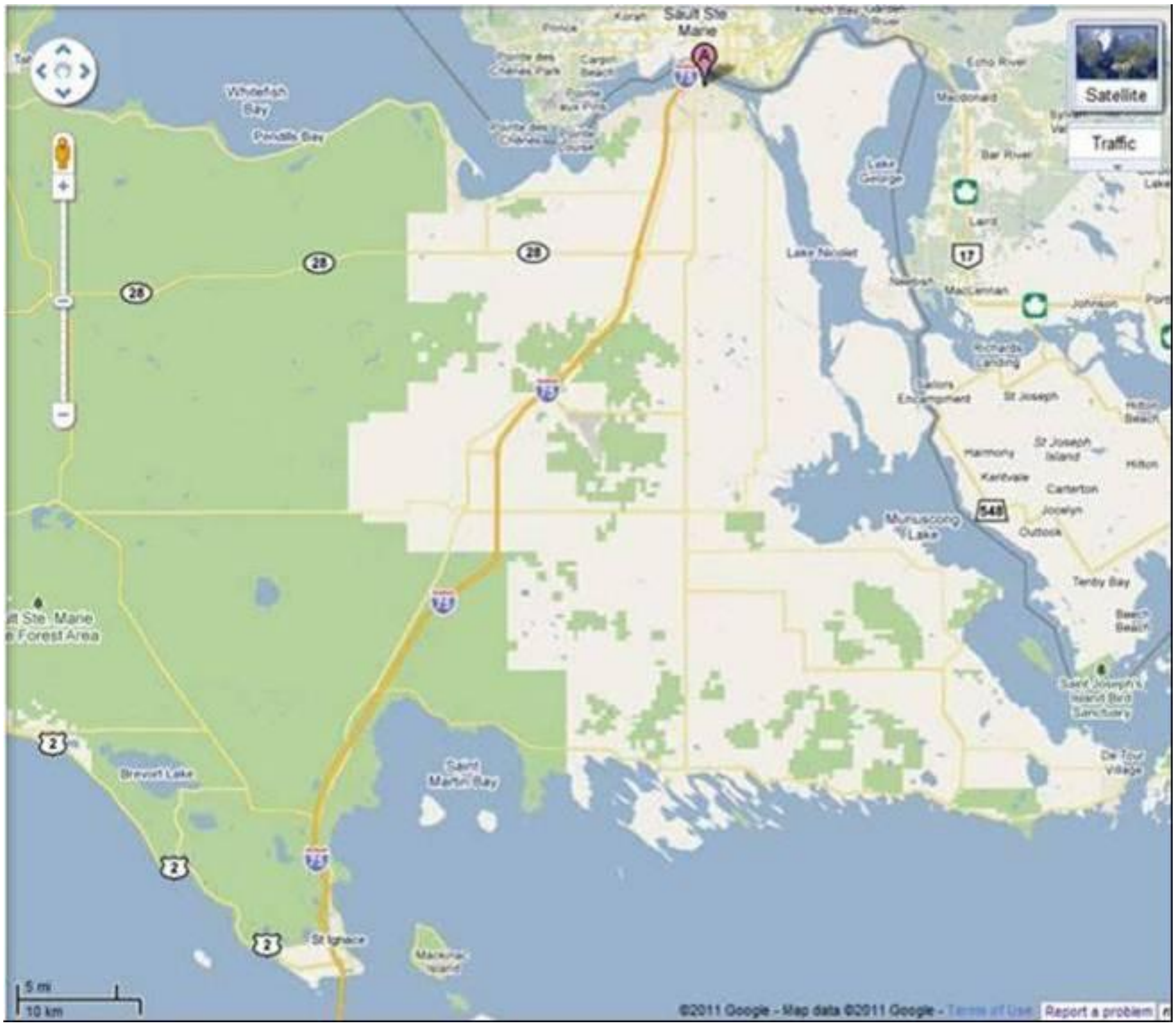

Figure F-1. The eastern upper peninsula of Michigan showing Sault Ste. Marie and St. Ignace.

F.3 Area of Demonstration

Figure F-2 depicts the area near the Straits of Mackinac, Michigan in which the demonstration was performed, indicating the location of the Enbridge Pipeline and Mackinac Bridge.

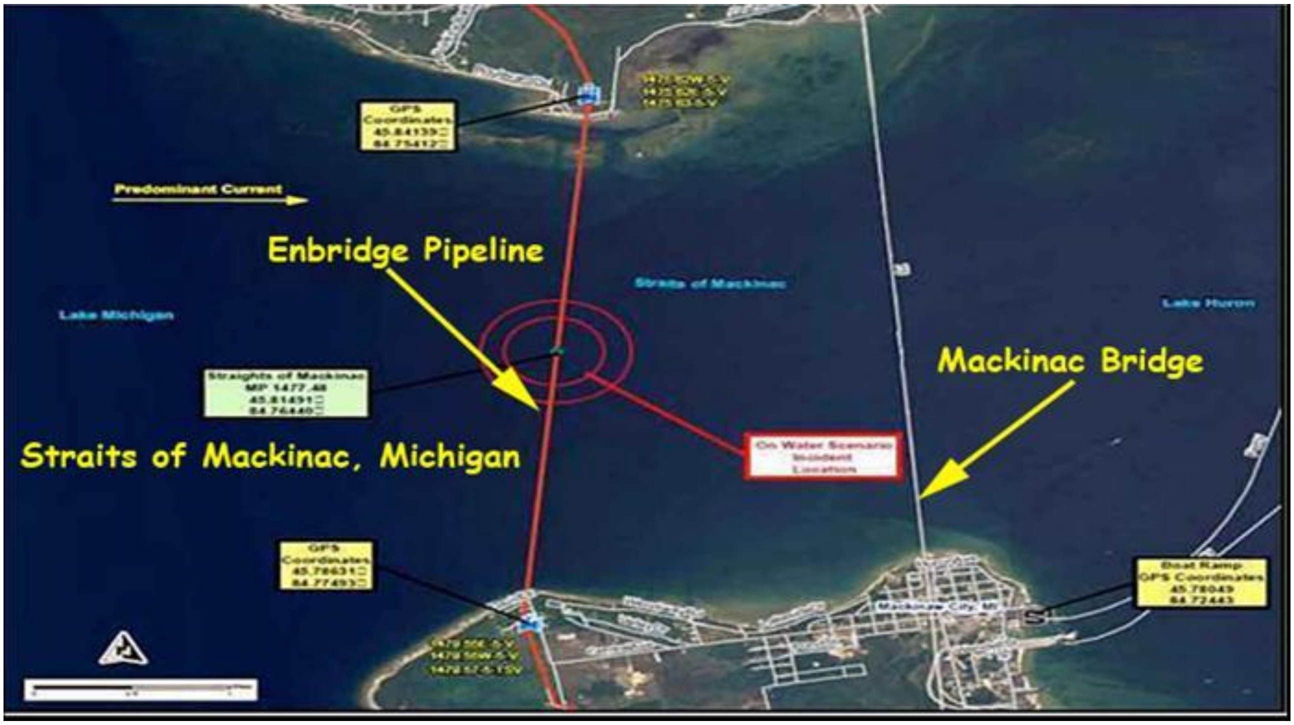

Figure F-2. Straits of Mackinac demonstration operating area.

F.4 CG Station St. Ignace

Figure F-3 shows the pier at CG Station St. Ignace from which the demonstration was staged. The pier was used for load-out and un-load operations as well as for daily mooring of the vessels participating in the demonstration. The CGC Hollyhock was moored to the left side of the pier as shown in the image and the three participating tugboats to the right side.

Figure F-3. CG Station St. Ignace pier (staging location).

APPENDIX G. TACTICS

These tactics are based on information found in: Alaska Clean Seas Technical Manual ("Alaska Clean Seas Technical Manual," n.d.) and the STAR Manual ("STAR Manual – State of Alaska," n.d.). Time and ice conditions permitting, these served as guidelines for tactics applied during the St. Ignace demonstration. Specific tactics and observations of their efficacy are given in the main body of this report. These are listed below:

G.1 Open Water Conditions
- G.1.1 Open Water - ISB
- G.1.2 Open Water – Skimming Operation
- G.1.3 Open water – Herding
- G.1.4 Open Water – Finding Collection Points

G.2 Ice Edge Conditions
- G.2.1 Ice Edge – Skimming Operations
- G.2.2 Ice Edge – Herding
- G.2.3 Ice Edge – ROV
- G.2.4 Ice Edge – Ice Management
- G.2.5 Ice Edge – Under Ice Retrieval
- G.2.6 – Ice Edge – Creating Inland Slot

G.3 Broken Ice Conditions
- G.3.1 Broken Ice Conditions – ISB
- G.3.2 Broken Ice Conditions – Skimming Operations
- G.3.3 Broken Ice Conditions – Herding
- G.3.4 Broken Ice Conditions – Large and Small Pockets
- G.3.5 Broken Ice Conditions - Slotting

G.4 Under Ice Sheet (Shoreline Only)
- G.4.1 Under Ice Sheet Conditions – Collection Pockets

G.1 Open Water Conditions

G.1.1 Open Water – ISB

Figure G-1 shows the tactic diagram for this condition. Table G-1 shows its oil collection assets and deployment data.

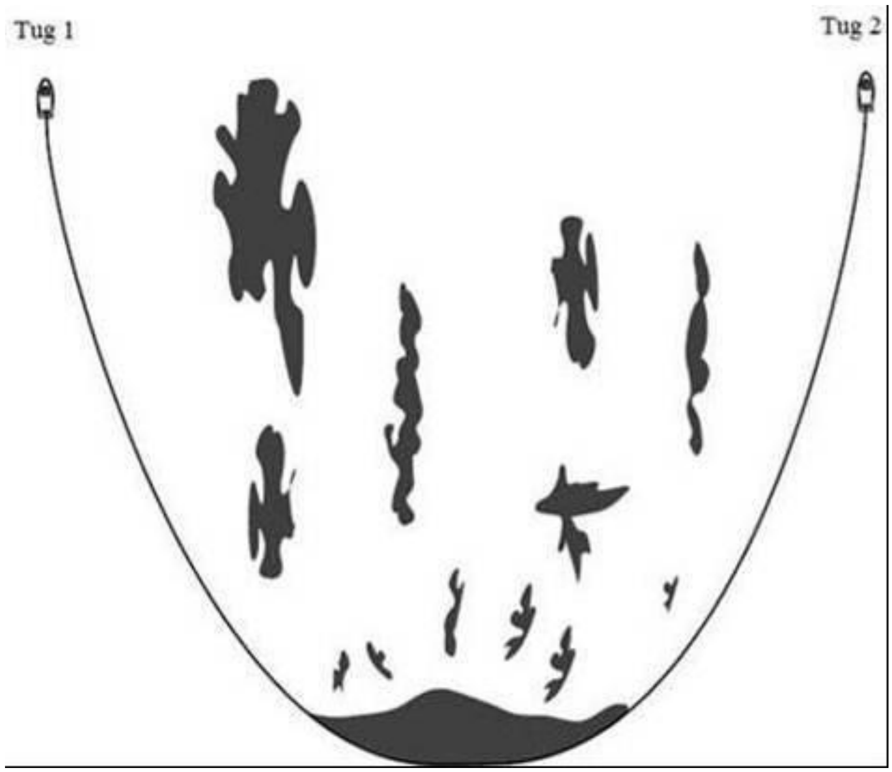

Figure G-1. Open water – ISB: tactic diagram.

Table G-1. ISB oil collection assets and deployment data.

Equipment	Function
Tugboat 1	Tow boom
Tugboat 2	Tow boom
PyroBoom	Containment, ISB

G.1.1.1 Open Water – ISB: Description

ISB is a technique to remove oil from the surface of the water before it reaches the ice or shoreline. Vessels must capture the oil and tow it to a safe location (defined by the Federal On-Scene Coordinator (FOSC) with respect to water depth, smoke plume, and distance from population and other responders) while moving at less than 1 knot. This tactic is enhanced if the wind is blowing away from populated areas and if the collected oil forms a thick enough layer (>2-3 millimeter (mm)) so it will burn better.

G.1.1.2 Open Water – ISB: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle and manipulate the fire boom in a safe and efficient manner.

G.1.1.3 Open Water – ISB: Measure

- Keep the surrogate (oranges and peat moss) inside the boom.
- Correlate with GPS positioning data.
- Ensure handling and support is adequate.

G.1.2 Open Water – Skimming Operation (Helix, Rope Mop)

Figure G-2 shows the tactic diagram for this condition. Table G-2 shows its oil collection assets and deployment data.

G.1.2.1 Open Water – Skimming Operation: Description

Mechanical containment and recovery at lakes or seas depend on the wave and wind conditions at the spill site. Wave heights exceeding 2 meters and wind speed greater than 35 kilometers per hour (km/h) should restrict responders from deploying skimmers as a response strategy. The Helix, drum, Polar Bear, and rope mop are deployed from a cutter or large vessel using a single boom or crane. When it is feasible to do so, containment booms can be deployed to intercept, control, and recover thicker slicks. The cutter/vessel movement is directed by aerial support to find and recover as much oil as they can while deployed.

In a rope mop skimmer, the floating rope is driven over the surface of the oil by a drive unit, which also squeezes the oil out of the rope for recovery. The rope is oleophilic (attracting oil) to remove the floating oil. The Helix and Polar Bear are circular brush skimmers with a rotating mechanism that shaves the oil off the brush and into a containment unit, and subsequently it is pumped out into a recovery tank.

G.1.2.2 Open Water – Skimming Operation: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to deploy and operate the skimmers in a safe and efficient manner.

G.1.2.3 Open Water – Skimming Operation: Measure

- Time and ease of deployment.
- Able to recover oranges.
- Ensure handling and support is adequate.

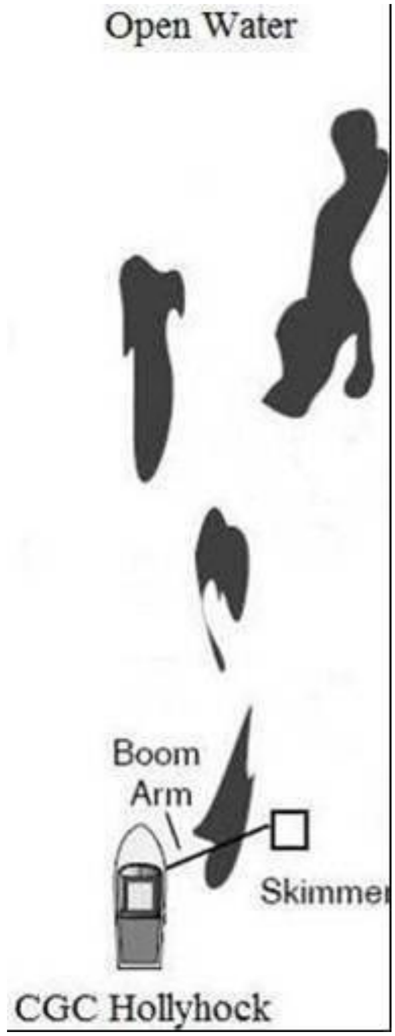

Figure G-2. Open water – skimming operation: tactic diagram.

Table G-2. Open water skimming assets and deployment data.

Equipment	Function
CGC Hollyhock	Working platform
Helix	Recovery

G.1.3 Open Water – Herding

Figure G-3 shows the apparatus mounted on a tugboat for open water herding. Table G-3 shows oil collection assets and deployment data for this condition.

Figure G-3. Open water – herding: apparatus mounted on a tugboat.

Table G-3. Open water herding assets and deployment data.

Equipment	Function
Tugboat	Working platform
Fire monitor	Herd surrogates

G.1.3.1 Open Water – Herding: Description

Herding is designed to move the oil slick into an area where it can be burned, contained, or recovered. It is usually done with a fire monitor that can move oil from a fixed location into a preferred area. In the open water, it is useful in gathering up wayward slicks into one mass for an easy recovery operation.

G.1.3.2 Open Water – Herding: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle a fire monitor and understand available strategies in corralling oil.

G.1.3.3 Open Water – Herding: Measure

- Able to swivel around on tugboat deck.
- Move surrogates into desired location.
- Ensure handling and support is adequate.

G.1.4 Open Water – Finding Collection Points

Figure G-4 illustrates oil collection pockets on an open water/sheet ice boundary.

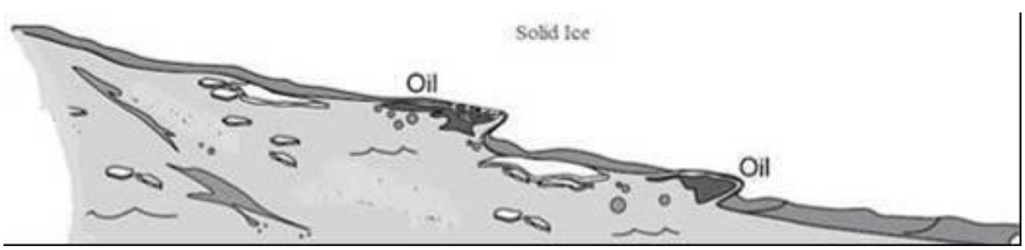

Figure G-4. Open water – finding collection points: oil collection pockets on an open water/sheet ice boundary.

G.1.4.1 Open Water – Finding Collection Points: Description

During most times of the year, oil gathers in natural collection points along the shoreline in locations where the current and waves are minimal. In ice conditions, oil also moves to these types of areas. Using the ice as a natural barrier for containment is crucial for recovery without pushing the oil below or on top of the ice. This is the first priority for utilizing the other recovery techniques.

G.1.4.2 Open Water – Finding Collection Points: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to approach and collect oil without disturbing or dispersing the collected oil. Another objective is to evaluate the use of herding to move oil into collection areas.

G.1.4.3 Open Water – Finding Collection Points: Measure

- Vessel can stand-off the location without contacting the ice.
- Vessel can stabilize location while skimmer is deployed.

G.2 Ice Edge Conditions

G.2.1 Ice Edge – Skimming Operation (Helix, Rope Mop)

Figure G-5 shows the tactic diagram for this condition. Table G-4 shows its oil collection assets and deployment data.

G.2.1.1 Ice Edge – Skimming Operation: Description

Mechanical containment and recovery at lakes or seas depend on the wave and wind conditions at the spill site. Wave heights exceeding 2 meters and wind speed greater than 35 km/h should restrict responders from deploying skimmers as a response strategy. The Helix and rope mop are deployed from a cutter or large vessel using a single boom or crane. When it is feasible to do so, containment booms can be deployed to intercept, control, and recover thicker slicks. The cutter/vessel movement is directed by aerial support to find and recover as much oil as they can while deployed.

In a rope mop skimmer, the floating rope is driven over the surface of the oil by a drive unit, which also squeezes the oil out of the rope for recovery. The rope is oleophilic (attracting oil) to remove the floating oil. The Helix is a circular brush skimmer with a rotating mechanism that shaves the oil off the brush and into a containment unit, and subsequently it is pumped out into a recovery tank.

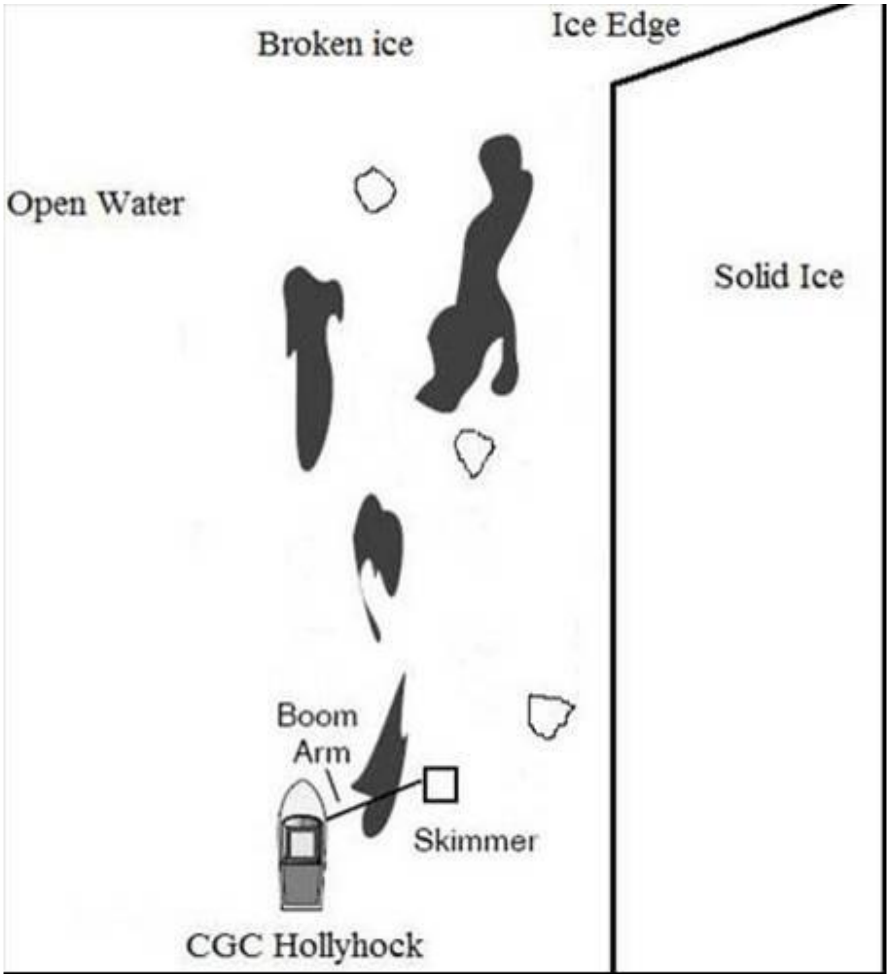

Figure G-5. Ice edge – skimming operation: tactic diagram.

Table G-4. Ice edge skimming assets and deployment data.

Equipment	Function
CGC Hollyhock	Working platform
Tugboat	Working platform
Helix	Recovery
Rope mop	Recovery
Heated drum	Recovery
Polar Bear skimmer	Recovery

G.2.1.2 Ice Edge – Skimming Operation: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to deploy and operate the skimmers while close to the ice edge without any damage to vessel or equipment.

G.2.1.3 Ice Edge – Skimming Operation: Measure

- Time and ease of deployment.
- Able to recover oranges.
- Avoid collision with ice edge.

G.2.2 Ice Edge – Herding

Figure G-3 above illustrates skimming tactics. Table G-5 shows oil collection assets and deployment data for this condition.

Table G-5. Ice edge herding assets and deployment data.

Equipment	Function
Tugboat 1 or 2	Working platform
Fire monitor	Herd surrogates

G.2.2.1 Ice Edge – Herding: Description

Herding is designed to move the oil slick into an area where it can be burned, contained, or recovered. It is usually done with a fire monitor that can move oil from a fixed location into a preferred area. In areas near the ice edge, herding is used to move oil along the edge towards a curve along the ice edge that can serve as a natural barrier to collect the oil for containment or recovery.

G.2.2.2 Ice Edge – Herding: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle a fire monitor and understand available strategies in corralling oil near the ice edge.

G.2.2.3 Ice Edge – Herding: Measure

- Able to swivel around on tugboat deck.
- Move surrogates into desired location.
- Avoid damage to vessel while maneuvering near ice edge.

G.2.3 Ice Edge – ROV

Figure G-6 shows pre-deployment of an ROV, applicable for near ice edge oil recovery operations.

G.2.3.1 Ice Edge – ROV: Description

This technique uses an ROV to search near the ice edge to look for oil that is under the ice. It could also be used down a hole if the ice is solid and personnel are deployed.

Source: U.S. Coast Guard

Figure G-6. Ice edge – ROV: ROV in process of being deployed.

G.2.3.2 Ice Edge – ROV: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle and manipulate an ROV while not disturbing the oil or the ice. Another objective is to determine if cameras are adequate for this task or if other sensors are needed.

G.2.3.3 Ice Edge – ROV: Measure

- Ability of local vessels to deploy equipment.
- Ability to locate specific oil and document location.
- Ability to deploy under-ice recovery techniques.

G.2.4 Ice Edge – Ice Management

Figure G-7 shows a vessel creating a channel of open water allowing oil to surface for recovery.

Source: U.S. Coast Guard

Figure G-7. Ice edge – ice management: vessel being used to create collection slot allowing oil to surface.

G.2.4.1 Ice Edge – Ice Management: Description

There may be many instances when the management of ice is required either to gain access to the oil or to keep ice away from the oil. Potential tactics include using vessels to move or deflect ice and creating collection slots for oil to surface.

G.2.4.2 Ice Edge – Ice Management: Objective of this Demonstration

The objective is to evaluate the ability of icebreakers to create slots similar to solid-ice response techniques and maintain open water. Another objective is to determine concept of operations for maintaining ice deflection away from oil locations.

G.2.5 Ice Edge – Under Ice Retrieval

If capable, the ROV or diver would be utilized to dive under the ice with an appropriate suction hose to find and recover oil before it gets to the shoreline. For this demonstration, discussions should focus on the capability of the ROV that is needed to do this.

G.2.5.1 Ice Edge – Under Ice Retrieval: Description

If the ice is not strong enough for personnel, techniques are needed that can permit an ROV or other mechanism to reach under and recover oil that is under the ice. Most current techniques assume that equipment and personnel can be deployed onto the ice but additional options are needed to deploy from vessels.

G.2.5.2 Ice Edge – Under Ice Retrieval: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle an ROV or other techniques to recover oil that has been pushed under the ice close to open water.

G.2.6 Ice Edge – Creating Inland Slot

G.2.6.1 Ice Edge – Creating Inland Slot: Description

This technique is designed to have a vessel create a slot and maintain open water to facilitate recovery. This slot could go to the shoreline to facilitate recovery at that location.

G.2.6.2 Ice Edge – Creating Inland Slot: Objective of this Demonstration

The objective is to evaluate the ability of icebreakers to create a slot and maintain it ice free.

G.2.6.3 Ice Edge – Creating Inland Slot: Measure

- Time and effort to create slot.
- Effort needed to maintain slot.
- Time that slot closes over.

G.3 Broken Ice Conditions

G.3.1 Broken Ice Conditions – ISB

G.3.1.1 Broken Ice Conditions – ISB: Description

ISB is a technique to remove oil from the surface of the water before it reaches the ice or shoreline. Vessels must capture the oil and tow it to a safe location (defined by the FOSC with respect to water depth, smoke plume, and distance from population and other responders) while moving at less than 1 knot. Broken or brash ice may be collected along with the oil but vessels do their best to avoid amassing a large number of ice pieces. This tactic is enhanced if the wind is blowing away from populated areas and if the collected oil forms a thick enough layer that would burn better. Figure G-8 illustrates broken ice conditions with the ISB boom encircling the brash ice. Table G-6 lists oil collection assets and deployment data for application of the PyroBoom. In areas where the broken ice is large and tightly packed, ISB is employed by using the ice as a natural barrier against which the oil concentrates.

G.3.1.2 Broken Ice Conditions – ISB: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to avoid as much broken ice and handle the fire boom in a safe and efficient manner.

G.3.1.3 Broken Ice Conditions – ISB: Measure

- Keep the surrogate (oranges) inside boom.
- Collect the least amount of broken pieces of ice.
- Correlate with GPS positioning data.
- Demonstrate onboard temporary storage.

Source: Joint Industry Program on Oil in Ice Report No. 27, May 2009

Figure G-8. Broken ice conditions with ISB boom encircling brash ice.

Table G-6. Data for PyroBoom deployment.

Equipment	Function
Tugboat 1	Tow boom
Tugboat 2	Tow boom
PyroBoom	Containment, ISB

G.3.2 Broken Ice Conditions – Skimming Operation (Rope Mop, Polar Bear)

Figure G-9 shows the tactic diagram for this condition. Table G-7 shows its oil collection assets and deployment data.

G.3.2.1 Broken Ice Conditions – Skimming Operation: Description

Mechanical containment and recovery at lakes or seas depend on the wave and wind conditions at the spill site. Wave heights exceeding 2 meters and wind speed greater than 35 km/h should restrict responders from deploying skimmers as a response strategy. The Polar Bear and rope mop are deployed from a vessel using a single boom or crane. When it is feasible to do so, containment booms can be deployed to intercept, control, and recover thicker slicks. The cutter/vessel movement is directed by aerial support to find and recover as much oil as they can while deployed. In broken ice, the vessel must try to get as close to an area of collected oil and use the boom/crane to place the skimmer in an area not occupied by ice. It must be carefully monitored so that it is not crushed by the bigger ice floes.

In a rope mop skimmer, the floating rope is driven over the surface of the oil by a drive unit, which also squeezes the oil out of the rope for recovery. The rope is oleophilic (attracting oil) to remove the floating oil. The Polar Bear is hexagonal shaped and is an off-shore ice skimmer that can process brash ice with oil.

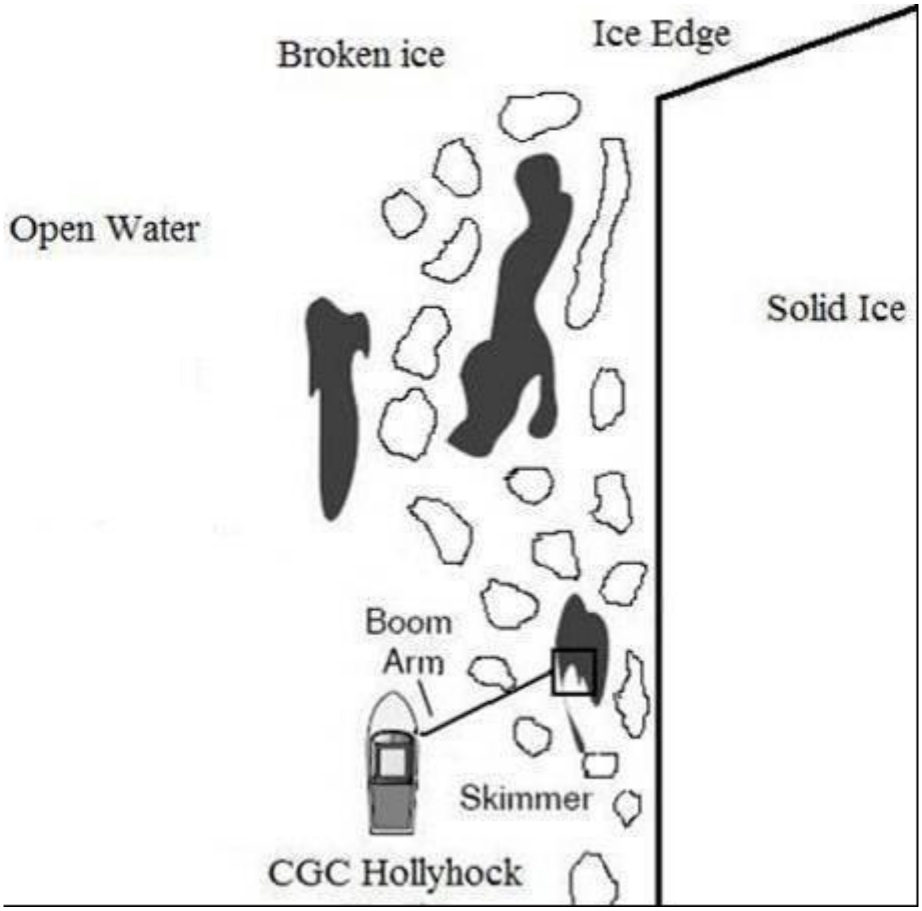

Figure G-9. Broken ice conditions – skimming operation: tactic diagram.

Table G-7. Broken ice conditions – skimming operation: oil collection assets and deployment data.

Equipment	Function
CGC Hollyhock	Working platform
Tugboat	Working platform
Polar Bear	Recovery
Rope mop	Recovery

G.3.2.2 Broken Ice Conditions – Skimming Operation: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to deploy skimmers in broken ice conditions without damage to vessel and equipment and recover surrogates.

G.3.2.3 Broken Ice Conditions – Skimming Operation: Measure

- Recover surrogates among broken ice in a safe and efficient manner.
- Deploy in hard-to-reach areas.
- Operate vessel safely.

G.3.3 Broken Ice Conditions – Herding

Figure G-3 above shows a tactic for skimming oil in broken ice. Table G-8 shows oil collection assets and deployment data for this condition.

Table G-8. Broken ice conditions – herding: oil collection assets and deployment data.

Equipment	Function
Tugboat	Working platform
Fire monitor	Herd surrogates

G.3.3.1 Broken Ice Conditions – Herding: Description

Herding is designed to move the oil slick into an area where it can be burned, contained, or recovered. It is usually done with a fire monitor that can move oil from a fixed location into a preferred area. Oil can be trapped in small spaces between bits of rubble ice, proving it to be inefficient for burning or collection of oil skimmers. It needs to be transported towards a more open area that is reachable by responders to conduct their recovery operations.

G.3.3.2 Broken Ice Conditions – Herding: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to handle a fire monitor and understand available strategies in moving oil to a more open area for adequate containment and recovery.

G.3.3.3 Broken Ice Conditions – Herding: Measure

- Able to swivel around on tugboat deck.
- Move surrogates into desired location.
- Able to herd ice.
- Avoid damage to vessel while maneuvering around ice pieces.

G.3.4 Broken Ice Conditions – Large and Small Pockets

Figure G-10 shows the tactic diagram for skimming pockets of oil in broken ice. Table G-9 shows oil collection assets and deployment data for this condition.

G.3.4.1 Broken Ice Conditions – Large and Small Pockets: Description

Ice floe shapes are widely unpredictable in an ice field so when an oil spill occurs, one may face large and small pockets of oil. The vessel would need to maneuver its way through the ice field and determine if the skimmer can remove the oil in the areas between the ice pieces.

G.3.4.2 Broken Ice Conditions – Large and Small Pockets: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to deploy skimmers in broken ice conditions without damage to vessel and equipment and recover surrogates.

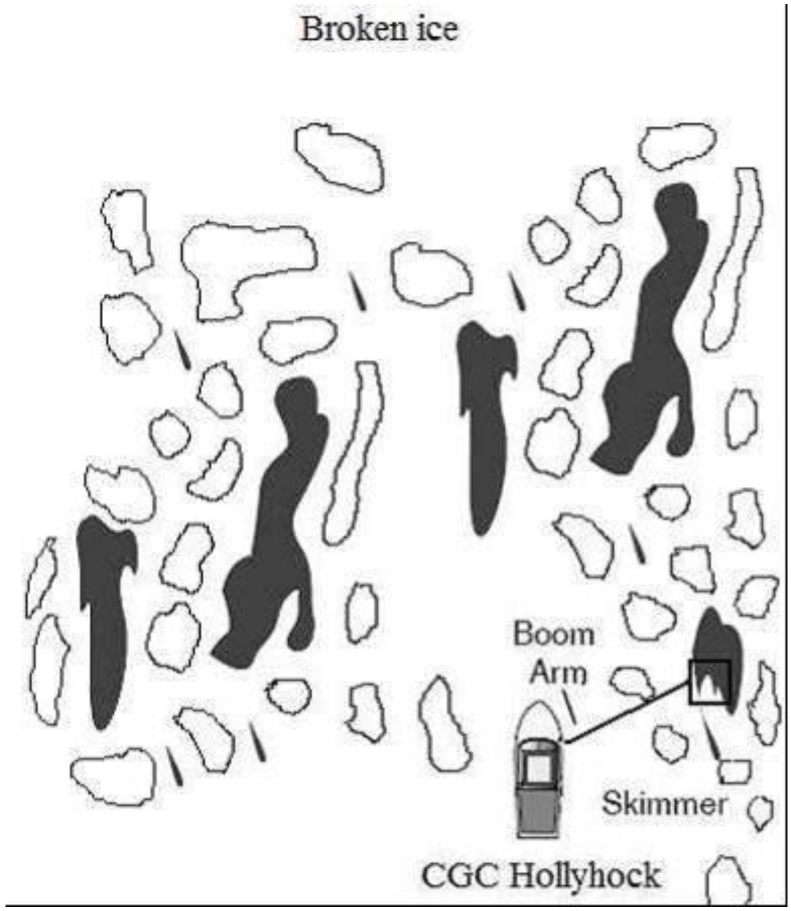

Figure G-10. Broken ice conditions – large and small pocket: tactic diagram.

Table G-9. Broken ice conditions – large and small pocket: oil collection assets and deployment data.

Equipment	Function
CGC Hollyhock	Working platform
Tugboat	Working platform
Polar Bear	Recovery
Rope mop	Recovery

G.3.4.3 Broken Ice Conditions – Large and Small Pockets: Measure

- Recover surrogates among broken ice in a safe and efficient manner.
- Deploy in hard-to-reach areas.
- Operate vessel safely.

G.3.5 Broken Ice Conditions – Slotting

Figure G-11 shows slotting tactics for permitting oil to surface and pool for easier collection. Table G-10 shows oil collection assets and deployment data for this condition.

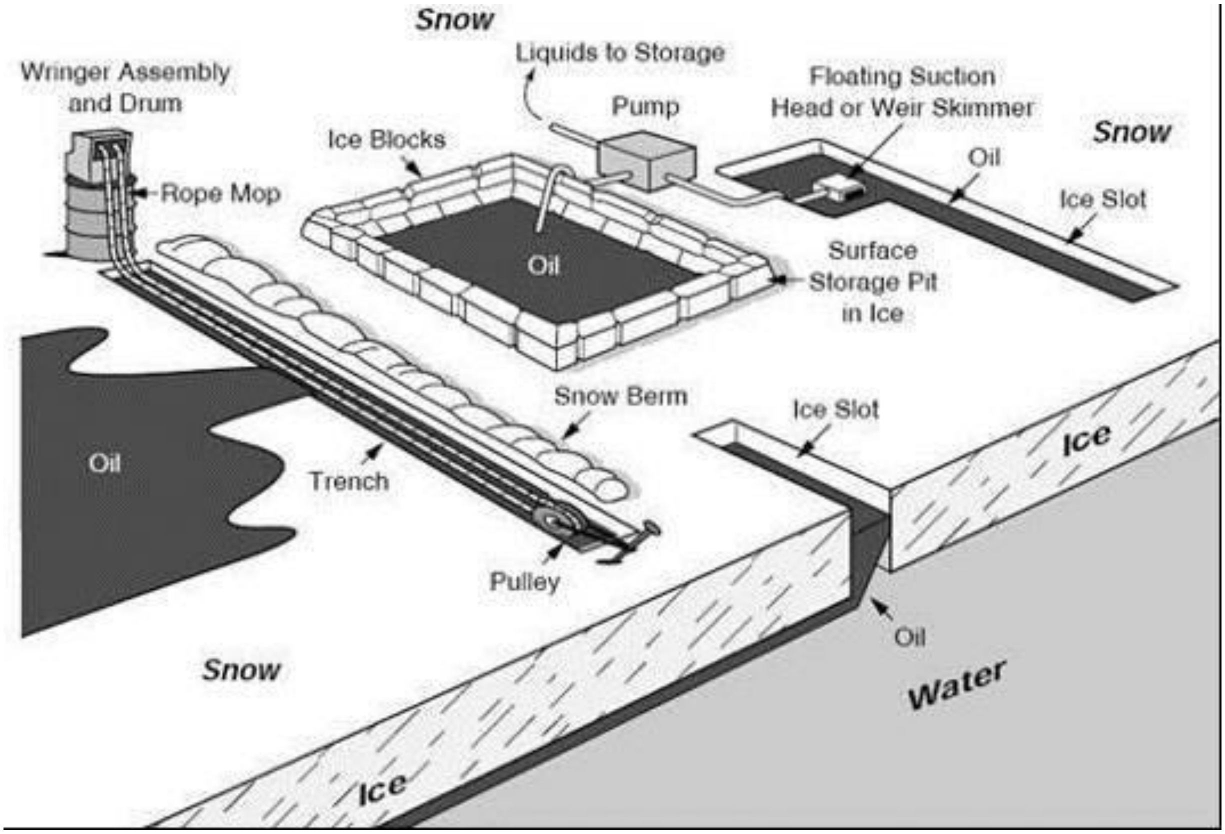

Figure G-11. Broken ice conditions – slotting: permitting oil to surface and pool for easier collection.

Table G-10. Broken ice conditions – slotting: oil collection assets and deployment data.

Equipment	Function
Tugboat	Equipment transport
Ice Auger	Recovery hole
Rope mop	Recovery
Helix	Recovery
Polar Bear	Recovery
Generator	Skimmer power

G.3.5.1 Broken Ice Conditions – Slotting: Description

Oil moving under ice that is big enough to stand on can be concentrated in slots cut in the ice and recovered by skimming with rope mops or other types of skimmers. If the oil is thick enough, it can be removed using direct suction.

G.3.5.2 Broken Ice Conditions – Slotting: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to recover surrogates under ice floes.

G.3.5.3 Broken Ice Conditions – Slotting: Measure

- Time of deployment.
- Ability to cut through ice.

G.4 Under Ice Sheet Conditions (Shoreline Only)

G.4.1 Under Ice Sheet Conditions – Collection Pockets

Figure G-12 shows a variety of methods of collecting and extracting oil from beneath sheet ice. Table G-11 shows oil collection assets and deployment data for this condition.

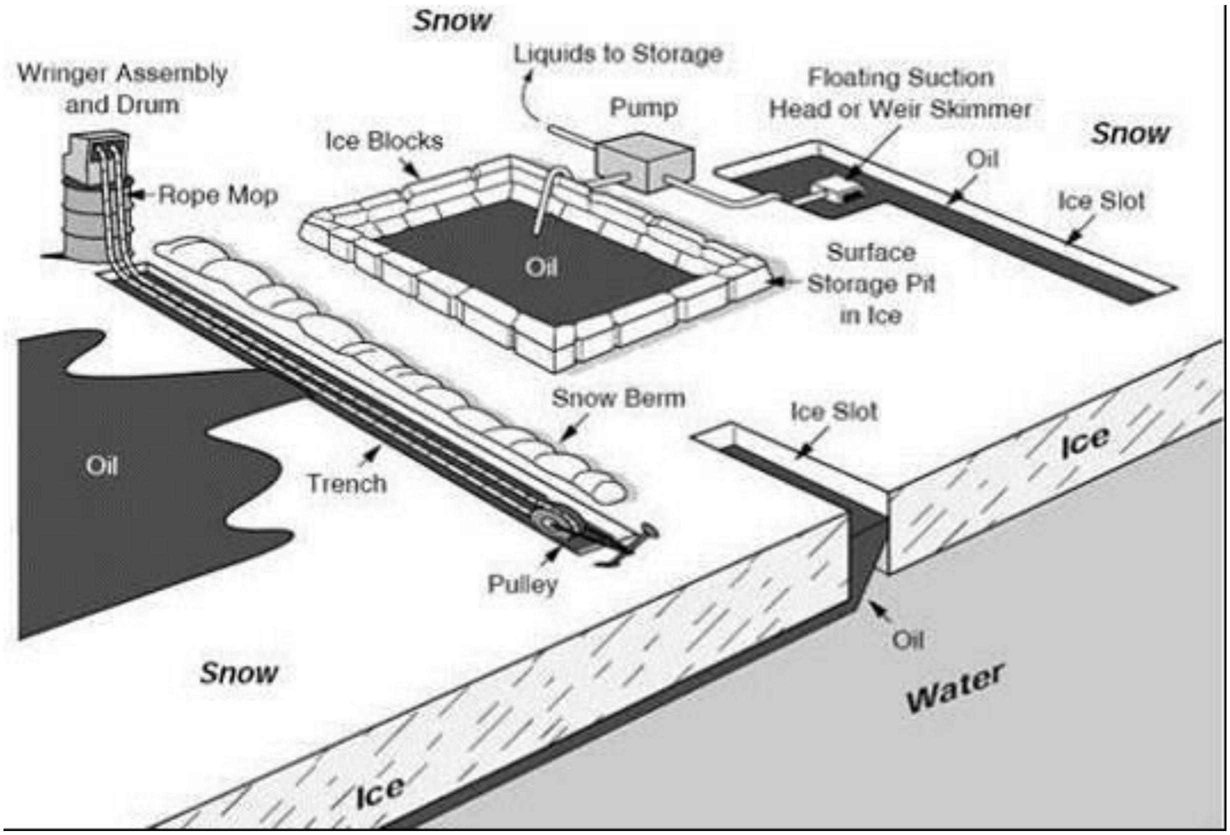

Figure G-12. Under ice sheet conditions – collection pockets: methods of establishing oil collection pockets in sheet ice.

Table G-11. Under ice sheet conditions – collection pockets: oil collection assets and deployment data.

Equipment	Function
Tugboat	Equipment transport
Ice auger	Recovery hole
Rope mop	Recovery
Helix	Recovery
Polar Bear	Recovery
Generator	Skimmer power

G.4.1.1 Under Ice Sheet Conditions – Collection Pockets: Description

Oil entrained in subsurface pockets can be reached by drilling holes with ice augers and pumping the oil directly to storage containers such as drums or bladders. It can be further separated or burned in a location agreeable to all parties.

G.4.1.2 Under Ice Sheet Conditions – Collection Pockets: Objective of this Demonstration

The objective is to evaluate the ability of local vessels to recover surrogates under a solid ice sheet.

G.4.1.3 Under Ice Sheet Conditions – Collection Pockets: Measure

- Time of deployment.
- Ability to cut through ice.

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